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Proceedings of COMSATS 1st Meeting on Science and Technology for Sustainable Development (October 8-9, 2001)

SPECIAL ISSUE

COMSATS

Commission on Science and Technology for Sustainable Development in the South

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SCIENCE VISION

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FOREWORD

Science and Technology in the current era have become the most important factor in leading any country towards the path of sustainable development and prosperity. The disparity that exists in the socio-economic conditions of the South and the North can be attributed to the amount of attention and resources that goes into this sector. Whereas the countries of the North appropriate substantial amounts of their resources for science and technology in general and Research and Development (R&D) in particular, their counterparts in the South are nowhere to be seen in the development picture. This is resulting in a greater North-South divide with the South at the receiving end.

Excessive reliance on the North in scientific and other areas without doing anything for internal capacity building has been another major cause of concern. The countries of the South despite having been endowed with rich natural resources are not in a position to fully exploit their resources due to regressive policies in the scientific and technological sphere.

*Realizing these critical issues that the South confronts today, Commission on Science and Technology for Sustainable Development in the South (COMSATS) at the request of its member countries organized a two-day meeting on "**Science and Technology for Sustainable Development**" on the 8th and 9th of October 2001.*

This illustrious gathering was participated by eminent scientists and leading lights from the member countries who shared their thoughts and experiences and presented their ideas and suggestions on how to elevate, by employing science and technology, the socio-economic status of the countries of the South and bridge the gap between the North and the South.

There were six technical sessions and each session comprised at least three presentations from speakers on different aspects of Sustainable Development. Each session was chaired by an eminent scientist from Pakistan's prestigious scientific institutions.

The meeting on the whole addressed the following important aspects of this problem:

- *a) Current situation and future prospects for sustainable development;*
- *b) Appropriate technology for sustainability of development initiatives;*
- *c) Harmonization of technological development with ecosystem;*
- *d) Role of services in any prospective structural shift in economy.*

The speakers came up with important recommendations that formed the crux of the meeting. These recommendations ranged from emphasis on pure and applied research, introduction of a curriculum based on science and technology, reliance on indigenous resources, capacity building, to allocation of substantial amount of capital for the rapid development of the countries of the South. The recommendations and the concluding note may be found at the end of the proceedings.

The proceedings of the meeting have been included in the special edition of COMSATS' quarterly magazine "Science Vision" which will provide the readers a ready reference to the details and developments of the meeting.

I would like to express my extreme gratitude to the COMSATS member countries, diplomatic community, speakers and participants of the meeting and my team for making COMSATS 1st Meeting on Science and Technology for Sustainable Development a huge success.

Dr. Hameed Ahmed Khan
Executive Director

Keynote Address

SUSTAINABLE DEVELOPMENT AND NUCLEAR TECHNOLOGY

*Ishfaq Ahmad**

The development in the world today is closely linked to development of new technologies and their maturation as industry. The industrial revolution, from the seventeenth to the nineteenth century, gave birth to the steam engine, textiles, printing press, etc. Countries that underwent this industrial revolution became developed, as machines took over some of the work from man; while countries that did not undergo industrialization remained underdeveloped and agrarian. This Industrial revolution had no direct linkage with science. However, the new technologies of the twentieth century were knowledge-based. Examples of these are: Nuclear technology, Space technology, Biotechnology, Information technology etc. Moreover, development in each new technology benefits other contemporary technologies; in fact, they reinforce one another. Furthermore, new technologies help generate knowledge, which further breeds newer technologies, thus leading to an explosive growth, both in science and in technology. Thus, there is a synergy in knowledge and technology. As no knowledge can be acquired as a black box, therefore new technologies also cannot be acquired as black boxes. For adoption and absorption of technology, a certain indigenous capacity is needed in the form of appropriate human development and S&T infrastructure. Each modern technology has an impact on all sectors of development, such as agriculture, human health, water resources, energy, etc.

For countries of the South, the problems of development extend far beyond the issues of economic strategy alone. Market forces that promote particular science and technology in the developed country do not exist in poor countries. There is a dearth of science and technology that is crucial to addressing the critical problems of countries of the South; science and technology in the South is generally both too little and too weak. Furthermore, there is an absence of informed and sound decision-making.

Some fundamental changes in outlook are needed, both in areas of science and in economic planning, for ensuring sustained development. Development requires the national economic plans to be intertwined with corresponding science and technology plans. The laboratory scientist, as well as technologist, has to learn business management, while the economist has to be aware of realistic potential of various new S&T applications. Scientists and technologists have to reach out to build partnerships with entrepreneurs in the private sector. World-wide strategic planning, by integration of the real human needs with the applications of science and technology, has to be undertaken to map a path across the fast-changing global scenario.

The concept of sustainable development has been elaborated in the Brundtland Commission report (1987). This report defines sustainable development as “the development that meets the needs of the present, without compromising the ability for the future generation to meet their own needs”. The major elements of development are food-security, sufficient availability of clean water, proper health-care, clean air and reliable energy-supply at affordable price, while ensuring the graded shift from agrarian to industrial economic strategies.

Nuclear Technology has the ability to contribute in a significant manner to all issues of development – indeed as a sustainable development. Let us now see in detail how nuclear technology can contribute to the sustainable development. Nuclear technology may be broadly divided into nuclear power applications and nuclear non-power applications. We will first take up the non-power applications. These applications are mainly in the fields of food and agriculture, medicine and health, water resources and industry, all of which are essential components of sustainable development.

NON-POWER APPLICATIONS

Agriculture and Food Security

Radiation-induced mutations produce better crops, which give high yields, are early maturing, have

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improved resistance to drought, salinity and/or to disease and insect-attack. There are now over one thousand, radiation-induced mutated crops in use, around the world and more are constantly being added. Nuclear Insect Sterilisation Technique (SIT) has been used extensively in Africa to eradicate the Testse flies; in the Mediterranean region, the Mediterranean fruit flies have also been eradicated through this technique, thus not only saving money but also protecting humans from the harmful effects of pesticides.

Radiation is being used in China and several other countries to preserve food, by eliminating bacteria and pathogens that can cause disease and even death. This technique has good potential, as it also protects users and the environment from the harmful effects of chemicals that are presently being used in fumigation of food. As Ozone depleting fumigation chemicals are banned, this irradiation technology has the potential to become increasingly indispensable for trans-boundary trade in agricultural products, as countries adhere to standards of food hygiene.

For sustainable agriculture, it is important to get the maximum benefit from agricultural inputs, such as fertiliser and water. Here, again, nuclear techniques are finding increased use in determining water and fertiliser-uptake, thus optimising their use. These techniques are also being used for mapping of micro-nutrients in the soil.

As far as Pakistan is concerned, agriculture is the mainstay of the country. Nuclear techniques are supplementing the efforts of the conventional agricultural research, e.g. nuclear techniques used in mutation-breeding have resulted in producing improved varieties of cotton, wheat, chickpeas, mungbeans and rice.

Salinity is a major problem in the canal-irrigated areas of Pakistan. Here, Isotope hydrology, in conjunction with biotechnology, can provide economic utilisation of saline soils. Pakistan Atomic Energy Commission's highly successful programme of reclaiming saline soil has received the support of the International Atomic Energy Agency (IAEA). An inter-regional IAEA model-project has initiated joint efforts with seven other countries, namely Morocco, Tunisia, Egypt, Syria, Iraq, Iran and Myanmar, for reclamation and utilisation of water-logged and saline wasteland.

Human Health and Medicine

Caring for human health is an essential component of sustainable development. Nuclear techniques are finding increased use in diagnoses and treatment of diseases. Nuclear medicine techniques are indeed powerful diagnostic techniques. Over ninety percent of all the produced radioisotopes are used in the area of health. Isotopes are also being used in nutrimental studies to track the intake of vitamins and other nutrients. Production of Radio-pharmaceuticals is increasing throughout the world, to meet an increasing demand. Radiotherapy is now an established technique for treatment of cancer. Its use will increase, as cases of cancer are increasing rapidly in the developing world. Another important use of nuclear technology is in sterilisation of medical products. A gamma-irradiation facility for sterilization of medical products, called Pakistan Radiation Services (PARAS), is currently running as a profitable commercial enterprise.

Water Resources

There is an increasing awareness in the world that fresh water is a precious and limited resource. All over the world, and in Pakistan, groundwater aquifers are shrinking due to over-exploitation, or are being lost due to degradation of water-quality from pollution caused by human activity. World-wide, the demand for water is increasing due to increase in population and higher standards of living. Global warming will put additional and increasing demands on water-requirements. Sustainable management of freshwater resources requires appropriate technologies. Isotope techniques, based on stable and radioactive isotopes, as well as radioactive tracers, offer effective tools for assessment and development of water-resources.

Isotope Hydrology is now being utilised in several areas, such as exploration and assessment of ground-water resources, especially in arid areas, surface and ground-water pollution, modelling of dynamic-processes affecting the movement of ground-water, surface-water, and precipitation, origin of salinity and impact on ground-water and assessment of geothermal resources, to name a few. One success story of isotope-hydrology is the study of Arsenic contamination of groundwater in Bangladesh. The problem of water-continuation by naturally occurring Arsenic confronted the government, and Isotope-hydrology was the only tool which could identify the source of water in different aquifers and thus identify safe aquifers. Sediment and seepage-tracing, through isotope techniques, is being used to study dam-stability and calculations of its life.

Global warming is now an established phenomenon. Investigation of atmospheric processes at micro and macro-scales is required to accurately predict future world-temperature and weather. Isotope techniques are now being used in investigation of precipitation and atmospheric processes; they are also being used in Paleoclimatic studies.

Industry

Non-destructive Testing (NDT) is an integral part of quality-control and quality-assurance requirement in a modern industrial plant. Nuclear NDT services are being used in a number of industries, including oil-refineries, fertiliser and other chemical plants, hydroelectric as well as thermal power-plants. Nuclear analytical techniques are used in laboratories for quality-assurance. Radiotracers and Nucleonic Control Systems are also finding use in industry.

NUCLEAR POWER GENERATION

Nuclear power-plants are operating in 30 countries around the globe. Sixteen percent of the world's electricity is now being generated through nuclear reactors. There are 438 operating nuclear plants running, safely in the world. The Key-factors for sustainability of any power option are sustainable supply of fuel, compatibility with environment and long-term economic viability. The long-term availability of different fuels is listed below:

Table - 1: The Long-Term Availability of Different Fuels

Uranium (once through)	150 years
Oil	40 years
Gas	60 years
Coal	200 years
Breeder Reaction	1000 years
Thorium Cycle	Several thousand years

It is obvious that, barring coal, no other fuel has any long-term sustainable supply opportunity. In comparing the pollutionability, we note that Coal is the most polluting, followed by oil, and gas, the nuclear cycle being the least polluting, as shown in the Table below:

Table - 2: GHG Emissions from Electricity-Production Chains (GCeq /kWh)

Nuclear	2.5-5.7
Wind Power	2.5-13.1
Large Hydro	4-6
Solar PV	27-76
Natural Gas	120-188
Oil	219-246
Coal	264-357

Long-term economic viability requires long plant-life and high plant-factor. The life of nuclear plants is being extended all over the world, especially in the USA, where there is a program to double the life of the plants. Plants-factors of up to 90 % are being achieved in Finland. Economic viability also requires security of supply; this is also in favour of the nuclear option.

Some negative aspects have been cited by the opponents of nuclear power; these are:

- Radiation effect;
- Safety and severe accident aspects;
- Nuclear-waste management and storage; and
- Proliferation.

We now discuss these, one by one:

Radiation is a fact of everyday life. On the average, natural radon gas accounts for 49% of radiation-exposure to humans, 40% exposure is due to cosmic radiation; only 11% is human-induced, almost entirely due to medical exposure. Serious environmental consequence of Chernobyl accidents compared to Three Mile Island (TMI) shows the importance of containment. Now, all new power-plants have measures for containment, even the Chernobyl type. There is also a large accumulated operational experience of over 9,000 reactor-years of operation, with remarkable lack of problems. No other large-scale technology, used world-wide, has a comparable safety record.

As far as nuclear waste is concerned, the quantities in question are remarkably small, relative to other industries. Small quantities permit containment strategies. If no reprocessing of spent fuel is done, the fuel can easily be kept in dry storage. If reprocessing is required, there are a number of technologies available; such as verification, cementation, etc. These are available in individual countries. Eventually, waste will be stored in deep underground storage-facilities, to prevent the radiation from affecting humans and entering the food-chain. As far as nuclear proliferation is concerned, nuclear power-plants are not essential for proliferation of nuclear weapons: the five original nuclear weapon states first developed nuclear weapons and then built nuclear power plants:

To summarise, world population is likely to keep growing for several decades yet, so the energy-demands will increase even faster. Renewable energy resources cannot provide most of these demands. Security of energy supplies is essential for sustainability. On all these counts, nuclear power has an edge over other power options. The future of nuclear power will, of course, depend on a number of factors, such as safety-record and public perception and awareness.

CONCLUSIONS

I wish to return to climate changes. The developed and the developing world have various divides, such as income divide, science divide and digital divide. There also is a climate divide. Poor countries, in general, constitute the tropical and arid impoverished regions of the world, while the rich countries are in the temperate region.

The anthropogenic climate-change, which is underway, is likely to impact far more heavily on the already poor world, than on the rich world. It is, therefore, of paramount importance for us to keep a close watch on the Global climate-change and gear ourselves to meet the new challenges.

Speaking of globalisation, it is becoming more and more apparent that the poor countries will remain in a disadvantageous position if globalisation remains restricted to trade. Globalisation should also provide equal opportunities by way of access to knowledge and skills. What is needed is a universal political will around the globe, to address the prevailing asymmetries and to promote knowledge-sharing as well as a sense of responsibility to use science and technology for peace and development.

Finally, the South will have to work together closely for sustainable development and alleviation of poverty, as the countries in the North will remain reluctant to address the real needs of the poor. In the light of this, initiatives such as the one taken by COMSATS deserve full support from all quarters.

SUSTAINABLE DEVELOPMENT AND INFORMATION TECHNOLOGY

*Hameed Ahmed Khan**

ABSTRACT

Information Technologies model the reality in such a way that information on it can be efficiently found and transported to the decision makers in a useful, readable form. There is still a need of standardization of nomenclatures, interchanging of formats and languages in order to accelerate the communicability of information so it can be useful for any decision maker or for the public.

But this standardization or modeling process increases the errors in interpreting the reality, which can lead to unsustainable decisions. However, the growing velocity of communication exchanges and the power of recent information technologies will probably reduce the standardization needs in time and allow a communication of less biased information that is more accurate for a better decision making process.

INFORMATION IN RELATION TO SUSTAINABLE DEVELOPMENT

The issue of sustainable development is at the heart of society setting the future course of humanity on the planet. This paper argues that irrespective of technological change--more powerful computers, satellite monitoring, even artificial intelligence--the issue of sustainable development will remain essentially the same in the high tech future of tomorrow. The concept of, as opposed to the term of, "sustainable development" is not new; the profound and complex problems subsumed by the term can be traced back to the earliest human civilizations and the perennial tension between population growth and economic development, on the one hand, and the use of natural resources and ecosystems on the other.

The term "sustainable development", however, is a recent invention, coming into common usage very recently. For example, the Brundtland Commission, which is responsible for most frequently cited definition of sustainable development states it to be the process “to meet the needs of the present without compromising the ability of future generations to meet their own needs".

The concept of sustainable development can be broken into two parts. On the one hand, "sustainability" relates to the question of the "carrying capacity" of the earth, while giving no attention to social issues, particularly those concerning equity and social justice. "Development", on the other hand, would appear to assume and even necessitate continual economic growth and ignore the question of ecological constraints or "carrying capacity". When these two concepts are put together, a very different one emerges, and the result is much more than the sum of the parts.

It is therefore a multi-dimensional concept, and it must be addressed at various levels simultaneously. Sustainability may be divided into three types: social, ecological and economic. The ecological definition is perhaps the clearest and most straightforward, measuring physical and biological processes and the continued functioning of ecosystems. Economic definitions are sharply contested between those who emphasize the "limits" to growth and carrying capacity and those who see essentially no limits.

In the narrowest sense, global sustainability means indefinite survival of the human species across all the regions of the world. A broader sense of the meaning specifies that virtually all humans, once born, live to adulthood and that their lives have quality beyond mere biological survival. The broadest sense of global sustainability includes the persistence of all components of the biosphere, even those with no apparent benefit to humanity**.**

IMPACT OF INFORMATION TECHNOLOGY

The development of novel and affordable information and communications technologies, and the emergence of information society with new economic models, has the potential for making major contributions towards sustainability of the earth’s ecosystems. Innovative use of information technology offers substitutes for travel and for the transportation of goods, and a major shift towards less resource-

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intensive production, consumption, trade, and services. Such changes can significantly reduce the environmental impact of industrial and commercial activities and thus contribute to sustainable development.

Today's information society is being built on technology, knowledge and intelligence. Information Technology (IT) empowers both people and machines with information, which is transformed into knowledge and intelligence. Appropriate use of the knowledge by both people and machines contributes to sustainable development. While informed and empowered people know their role as citizens in an environmentally sustainable society, empowered machines have the knowledge to minimize energy and material use, wastes, and pollutants.

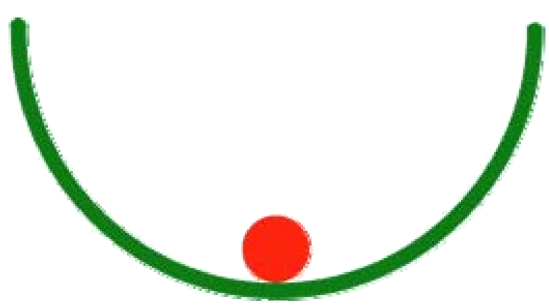
Information technology facilitates fast, cheap, equitable, and resource-efficient access to information, accumulated knowledge, learning opportunities, and co-operation support tools for its citizens. Internet, today's cyberspace, facilitates people from across the globe to co-operate and perform various activities of human life and endeavour. Processing, storage, transmission, and sharing of information in electronic form, without any spatial or temporal constraints, empower people with instant information along desired lines. Information analysis contributes to knowledge and intelligence, which have increasingly become commodities in the information age. As information becomes accessible to anyone, and anywhere, it is increasingly becoming a basic economic resource and a structuring factor in today's society.

Miniaturization and innovation in electronics have equipped machines with intelligence and communication technologies, enabling them to collaborate with each other in their work. By empowering machines, IT offers a high potential for making a positive contribution towards sustainability of our economy and environment, particularly by reducing the impacts arising from manufacturing and transportation activities. However, such opportunities are emerging in various other sectors too.

VIEWS OF ENVIRONMENT

1. Nature is Robust

The environment is seen to be very forgiving of human impacts and is virtually inexhaustible as a resource base. Represented graphically, it can be represented by a ball rolling inside a steep-sided basin, where, no matter what changes affect the system, it ultimately returns to the bottom of the basin. In its purest form, this myth views global environmental change in terms of a positive challenge; as new opportunities for human ingenuity. It is assumed that green technology, will prevent, correct, or even restore, any unanticipated damage to the environment. This is essentially an individualist view of the world, in which the invisible hand of markets are seen to be the only necessary regulatory mechanism for the system. This view is broadly supported by many activities in business and industry. (*Technology and Sustainable Development)* [1]

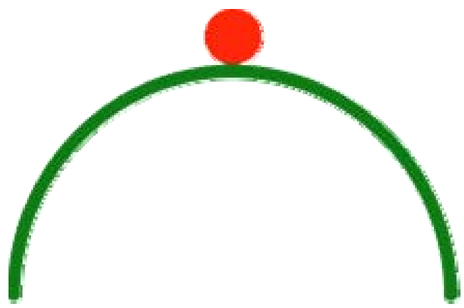


NATURE IS ROBUST
Individualist

Figure - 1(a)

2. Nature is Fragile

The environment is seen to be vulnerable to irreversible collapse due to ecological degradation or natural resource exploitation. Graphically, it can be represented by a ball precariously balanced on an upturned bowl. In its purest form, this myth views global environmental change as a manifestation of the multiple negative human impacts on the environment. It is assumed that a continued advance along society's current materialist path will ultimately lead to the irreversible destruction of the planet. This view is an egalitarian one and has been embraced by the deep ecologist movement, which suggests that a fundamental transformation of contemporary society is necessary; either through the return to the frugality of traditional societies or through the creation of a universal "earth ethic" with strict moral principles. Fragility images are also used by other groups.

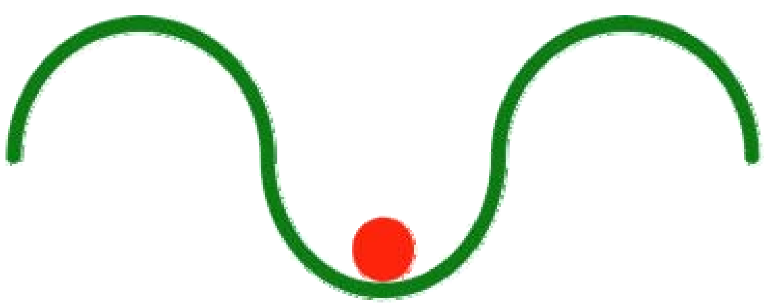


NATURE IS FRAGILE
Egalitiarian

Figure - 1(b)

3. Nature is Robust Within Limits

The environment is believed to be resilient within identifiable limits that must, however, not be surpassed. Graphically, the ball is most likely to remain at the stable point at the centre of its system, but the sides of this depression cannot exclude the ball from being bumped over one of the edges. This view is essentially a hierarchic one, which assumes that ecological degradation and the use of natural resources need to be carefully monitored and managed by a specific body. It assumes that global catastrophe can be avoided through the accurate scientific understanding of ecological limits and the establishment of standard operating procedures. This view is particularly popular amongst some governments and the United Nations system, which envisage a type of global bureaucracy to manage the environment. Economic growth can be maintained through rational management.

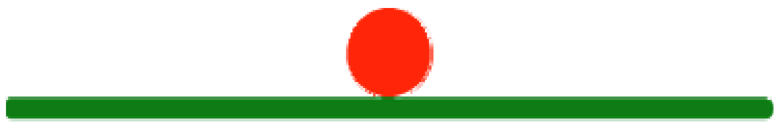


NATURE IS ROBUST WITHIN LIMITS
Hierarchist

Figure - 1(c)

4. **Nature is Chaotic**

The system is seen to be essentially chaotic and unpredictable. Graphically, the ball indiscriminately moves on a flat plane, devoid of vertical perturbations, continuing on a flat plane forever (there are no edges to fall off). Meaningful or significant change is impossible. This is a fatalist view; life is like a lottery: It is driven by luck, not skill. For obvious reasons, proponents of this view do not often articulate their views, because management strategies, in any common sense of the word, are reduced to just surviving as best as one can.



NATURE IS CHAOTIC
Fatalist

Figure - 1(d)

If one of these four views were actually the correct one, we can assume that eventually all opponents would be converted to that belief system simply by experience and the occasional surprise. Yet, among the competing views, although they wax and wane, one never obliterates the others, nor does any view simply fade away --they persist. Instead, the fact that we continue to be surprised suggests that the natural world has many, ever-changing faces, fitting each of the different views at different times. Various groups hold different perspectives on "sustainable development". Each of these views is given as "proof" for the necessity of a particular strategy or action. Opposing interpretations are rejected. Other views are not seen as simply misguided, but are instead perceived to be blatantly wrong and threatening. Many people who adhere to a particular view of the environment --although they might deny this categorization-- are so firmly (or blindly) committed to their own view that they refuse to recognize competing views as having any legitimacy. We need a more open debate on sustainable development; one which is based on the rejection of a single world view or environmental strategy. There is validity in each viewpoint, and each is correct in different contexts.

The multiple views of sustainable development are not only equally legitimate, but absolutely necessary to the health of the debate. Sustainable development can be successfully implemented only if each view makes its unique contribution to the solution. Since each represents only a part-truth, there is no single solution to a given environmental problem. In other words, sustainable development strategies cannot be attained through the dominance of a single view or by the exclusion of others; instead they require continual evolution and exchange.

SOME STATISTICS IN GRAPHICS

The following are some graphical representations of IT penetration and usage in various sectors of economy in various countries of the world:

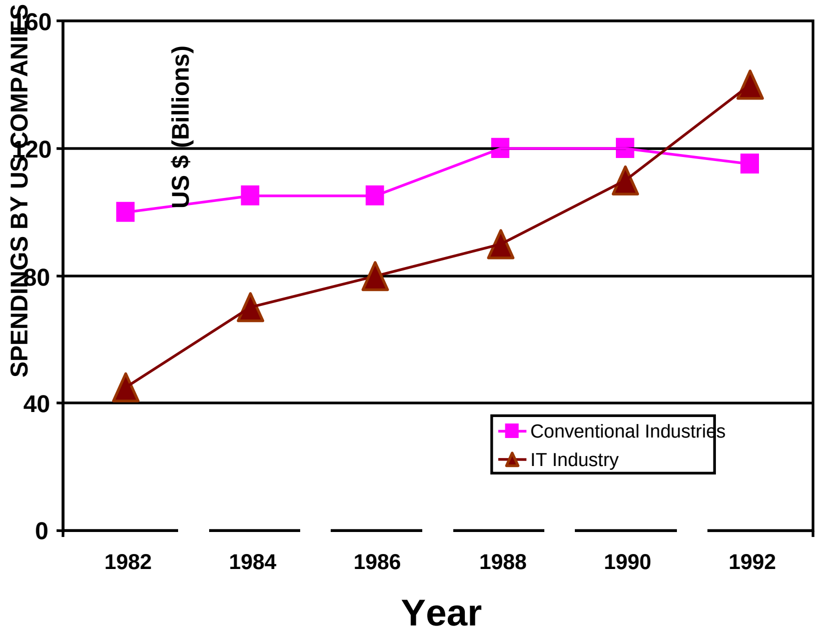


Figure - 2: Spending by US Companies in Conventional Industries vis-à-vis IT Industry)[2]

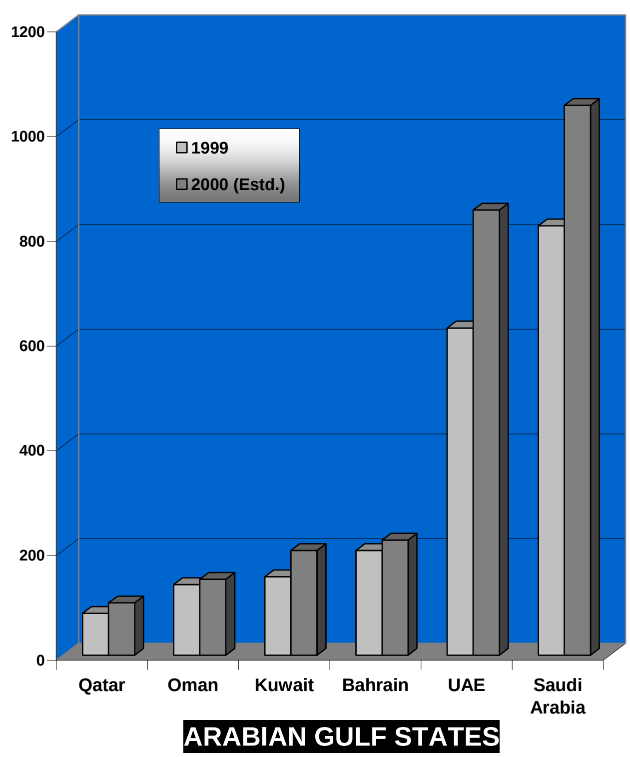


Fig - 3: Histogram Showing Market Size (IT) in Various Arab Countries[3]

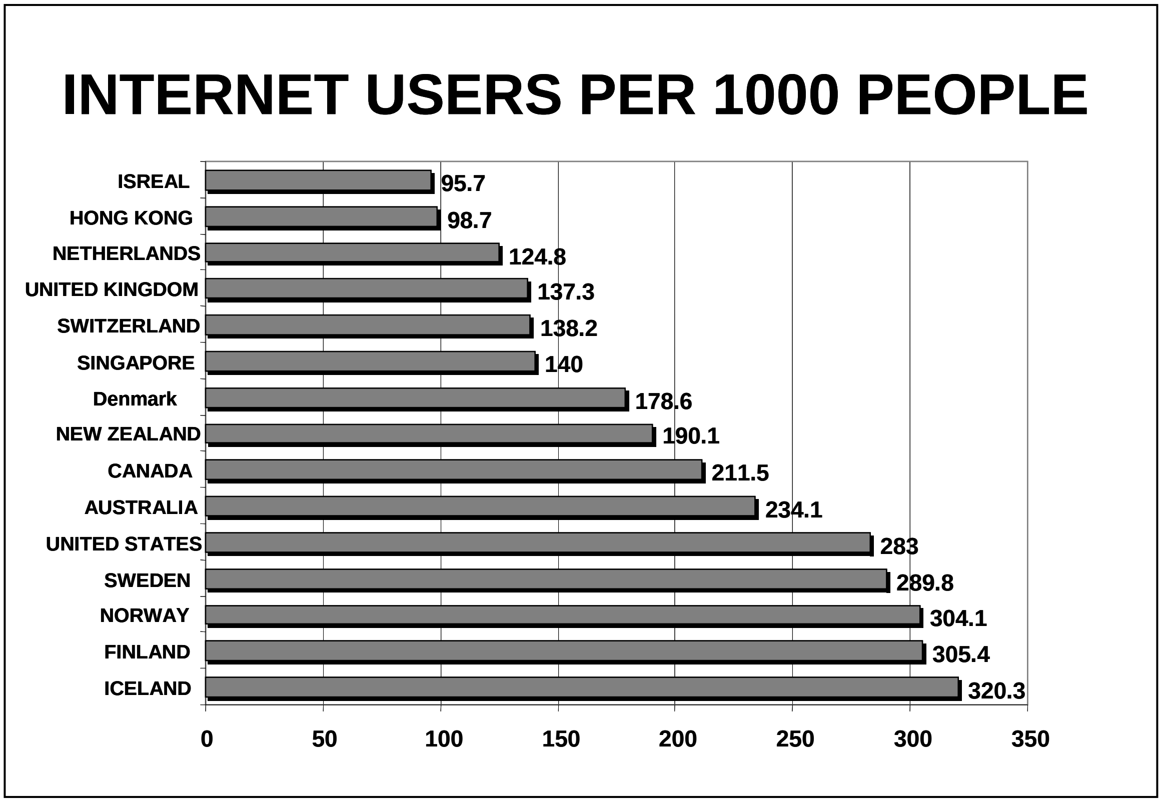


Figure - 4: Graphical Representation (i) of Internet Usage Per One Thousand Persons in Various Developed Countries[4]

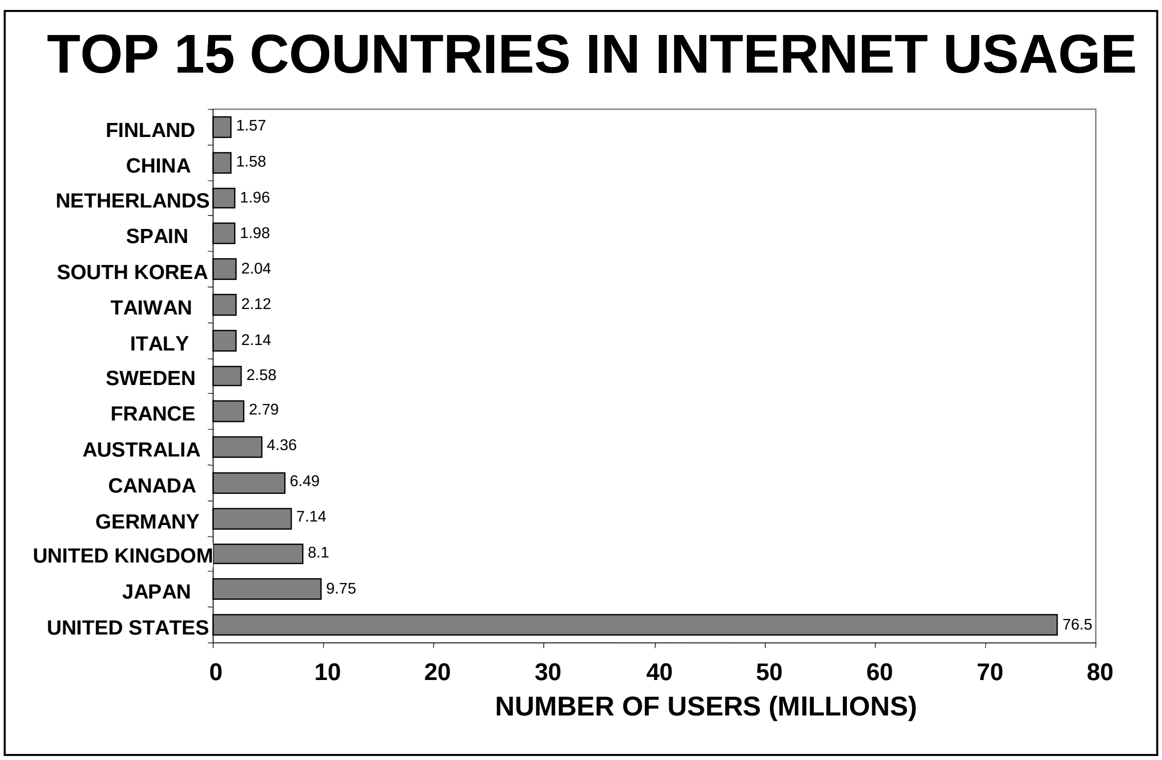


Figure - 5: Graph Indicating Top 15 Countries In Terms of Internet Usage[4]

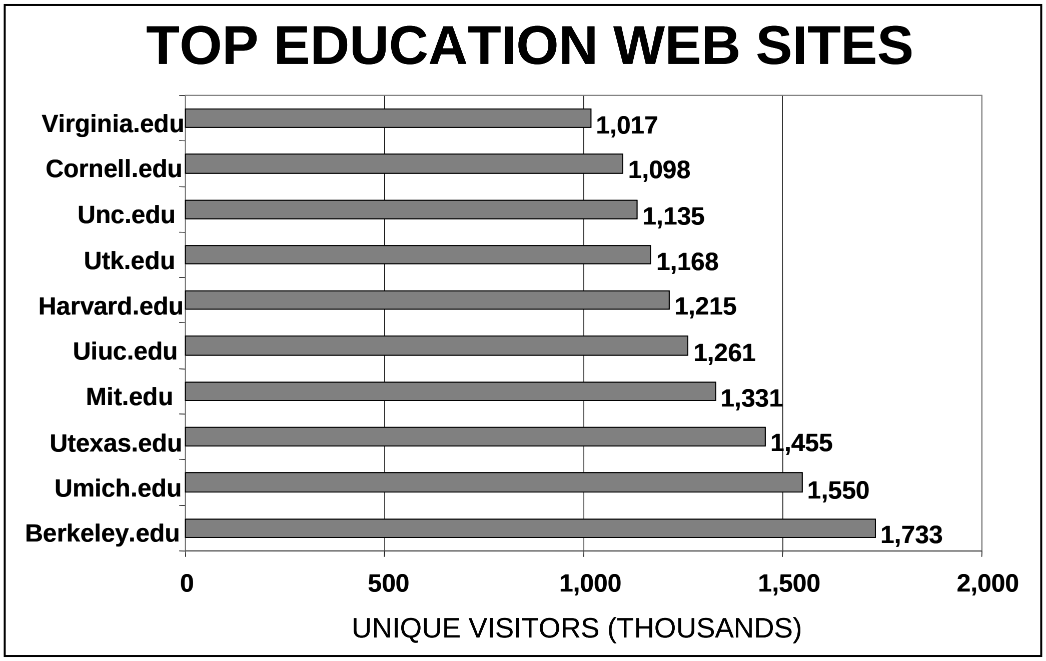


Figure - 6: Top Education Websites In Terms of Visitors[4]

Figure - 7: Top Shopping Websites In Terms of Number of Visitors[4]

POTENTIAL OF IT TOOLS IN SOME SELECTED SECTORS

1. Manufacturing

Because they provide flexibility, open systems will be the key for the manufacturing organization of 2020 and beyond. Typically, one has to design a product to meet a particular need, then quickly hone in on the design, sacrifice design flexibility and create a product that cannot evolve and meet new needs. The Information Revolution gives the flexibility to postpone commitment of resources to a particular course of action until the last minute, allowing us to make better decisions about our design before the freedom to make those decisions is lost.

Competitive advantage will go to companies that provide exactly what their customers want at a low cost. For most people, it's the latter and they shouldn't have to pay more for it. Such flexibility means the future of manufacturing could hold economies of scope, in which cost reductions on a group of products are achieved through components which are shared by all the products. This approach differs from the concept of economies of scale, which today offers large amounts of a specific product.

2. Transport

a. Tele-working and telecommuting can be acceptable substitutes for local and long distance travel.
b. Microprocessor engine control systems can save fossil fuel and reduce pollution.
c. Advanced transport tele-matics (ATT) can improve transport efficiency and road safety.
d. Intelligent transport systems can reduce travel time, improve traffic flow and help to make the roads safer.

Some of these technologies are fibre optics, computers, networks, improved human-computer interfaces, digital transmission and compression, communication satellites and cellular devices. They are influencing interactions among states, international governmental organizations such as the United Nations, multinational corporations and non-governmental organizations.

3. Agriculture

Modern agricultural production systems continue to demand increasing levels of intensive management, to help farmers maintain a competitive edge. Computer programs are used by farmers to assist in record keeping and enterprise analysis. However, many computer packages which are available are used to record activities in progress in the production process or financial activities.

There are few which express the production process in financial terms.

Sustainable food system benefits from the responsible use of resources by farmers who perform a wide variety of tasks as part of crop management. These tasks can be facilitated by expert systems with the knowledge, designed and built with the help of local expertise. Land information system prepared using Geographic Information Systems (GIS) and remote sensing can help farmers plan their activity and facilitate decision making and planning at the local level.

4. Environment

IT systems can provide improved access to environmental information to citizens, authorities at every level, NGOs, and businesses for environmental monitoring and management. GIS and remote sensing can be used to map resources, land-use patterns and environmental factors. This could help bring about more effective planning, management, and decision-making with regard to the environment.

Moreover Information systems can facilitate a national and worldwide dialogue about policies needed to ensure that sectoral growths are consistent with an improved environment. The environmental community has been painfully slow to recognize the power that information tools can bring to this debate.

5. Education

“Education technologies" is a phrase commonly used to refer to whatever the most advanced technologies available are for teaching and learning in a particular era. Throughout history, humans have invented technologies that radically change what they're able to see, do, and think about over significant time scales.
Microscopes-medicine-health; the printing press-books-literacy and news-we've used technologies to

craft new environments in which we live, which then change human life by changing what we do in fundamental ways, and even what we think about what humans are. Consider artificial intelligence and biotechnology efforts such as the human genome project

In this context, we see a redefining of the very roots of learning and education underway with new computing and communications tools. Education in the context of such societal transformation as this should not be "business as usual," only making the learning of the past achieved through greater efficiency. For example, technology is changing the "what" of learning by introducing new concepts, techniques, and tools for understanding and also making the world-for inquiry, design, creative expression. These innovations include computer-aided design, simulations of physical systems that model climate change, the origins of the universe, or ecosystem population dynamics, as well as new ways to visualize and integrate data and to carry out radically new forms of inquiry that weren't possible until recently. Micro-worlds provide children in these early years with understandings of Newtonian mechanics and about sensors and graphing and feedback in complex systems. In addition to shifting the time and place of learning through wide-area networking, new participants in on-line communities are also learning from one another across school and age boundaries, including scientists, scholars, parents, and senior citizens.

Yet technology in and of itself is not a panacea for education and its applications can surely be misguided. Computers and communication technologies are clearly not solutions alone, nor do they automatically foster utopias. Technologies can carry or promote virtually any value system into the classroom, including outmoded methods of instruction. And, of course, it takes more than computers and Internet access per se to improve education. We can get beyond that.

6. Others

a. Saving paper: Electronic information processing and dissemination can save the forests.
b. Arresting urbanization: Ready and adequate access to information, knowledge, and telecommunications in rural areas would discourage urbanization.
c. Tele-medicine: Tele-medicine can provide medical care to people in their homes, and to patients in remote areas.
d. Empowering citizens with information: By creating suitable contents on cyberspace and making it available at info kiosks in their close proximity, preferably in the local language and covering local issues among others, will empower citizens with the knowledge to act to bring about sustainable development.

TRANSLATION TOOL OF INFORMATION TECHNOLOGY

We will concentrate here on one 'translation' tool that would have a positive effect on the communication for a more sustainable world. (Technology Tools for Sustainable Development) [5]

The Information Paradox

Each language is a modelisation of the reality that reflects the culture behind it. The modelisation of the reality through information accelerates the possibility to manage it. More the real world is modeled, quicker the management of information is and so is the response and further impact to reality. But also, further is the answer from the reality, and bigger is the risk of error. This information paradox cannot be solved, but information technology could help to reduce its size.

Figure 7 illustrates the process of making synthetic information by successive modelling of the reality. Agenda 21 (UNEP, 1992) and the United Nations Commission on Sustainable Development (1995) agreed that a set of new indicators would be necessary for sustainable decisions. Basic data are more close to the reality, but are not workable for the decision makers. Derived data, indicators and indices give a more readable image of the reality and can be compared, aggregated, combined, discussed, presented in charts and maps for a better implication of the different actors involved in the decision making process. Indices and indicators are more visible, even if they are far from the reality. It is the information paradox.

Here we face a problem of standardisation of the metadata: if each library, each catalogue, each address list uses other conventions, no communicability is possible, no information can be found by external people, which is not the goal of Agenda 21 statements. The necessary standardization of data format is stated by all international agencies, but also within countries, e.g. between regions or administrations.

Metadata standardization is easy if only a small set of descriptive elements are used: author, title or name, address, keywords, summary. It is difficult if more details on the source are given (for example: which language to use for full text description?). The cost of listing a lot of data sources is also much lower if a single title or name is used, but a catalogue of data sources is more useful if more descriptions are given.

We face the paradox of data retrieval pyramid, illustrated in the figure: on the lowest level, data are well described (the extreme is that the data themselves are stored), but difficult to harmonize or to collect within a single system, on the highest level, it is easier to make comprehensive lists, but the metadata are too far from the data they are suppose to describe.

This paradox of describing and retrieving data and information is also not solvable: more modeling of the reality gives more visibility and communicability but are more biased and does not represent well the quality of a data source. But information technology, and in addition the generalization of metadata standards, can also help to reduce the size of the paradox.

INFORMATION COMMUNICATION-STANDARDIZATION

The Figure 8 shows the structure of information interchanges today on the Internet, with a view to the future. Standardization seems to be one of the crucial points to solve today. If English is already the main key language of the Internet, the system is evolving to the use of metadata standards in the header of each document, in order to allow the search engines to find the relevant information from the users point of view.

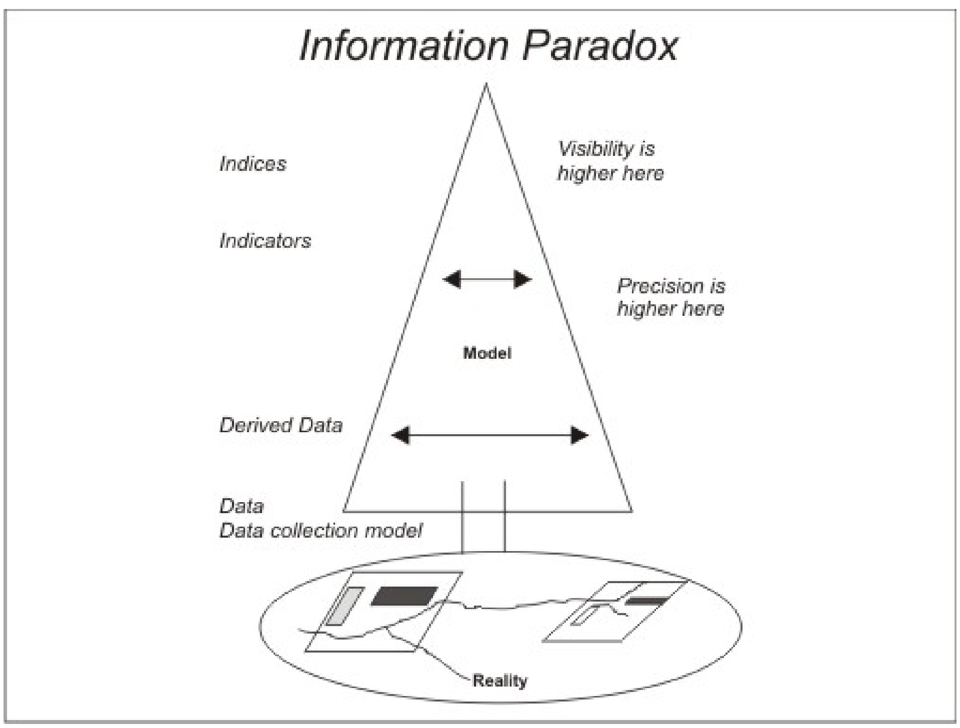


Figure - 8: Communication Through the World-Wide Computer Network.

Data about data are called metadata. The role of meta-databases is to accelerate the research of information for specific use. A good example is the bibliographical meta-databases used by the libraries.

A title, a summary and keywords help to index the data sources. It works well within a single library, because the keywords used are adapted to the needs of the specific user's community. But for the description of other types of data or information sources, such as organizations, experts, databases, samples, satellite images, projects etc., the system of the libraries is not sufficient, and a more complex set of descriptive elements are needed (quality and size information, languages used, formats, addresses). Otherwise, the relevant data sources are not found by the users. In a world wide environment, where potential data providers and users are not of the same culture and do not speak the same language, this problem is even more accurate.

Here we face a problem of standardization of the metadata: if each library, each catalogue, each address list uses other conventions, no communicability is possible, no information can be found by external people, which is not the goal of Agenda 21 statements. The necessary standardization of data format is stated by all international agencies, but also within countries, e.g. between regions or administrations. Metadata standardization is easy if only a small set of descriptive elements are used: author, title or name, address, keywords, summary. It is difficult if more details on the source are given (for example: which language to use for full text description?). The cost of listing a lot of data sources is also much lower if a single title or name is used, but a catalogue of data sources is more useful if more description is given.

INFORMATION COMMUNICATION: TODAY & TOMORROW

This implies that to allow communication for sustainable development, it is necessary today to improve:

- *Information storage and processing infrastructure,*
- *Communication channels and terminals (80% of the world's population have no access to the telephone);*
- *Interactive communication efficiency and velocity.*
- *Standardization (of data, of metadata, of interchange protocols and formats);*

The two first points will depend on:

- *Reduction of the costs of IT;*
- *Policy of equal distribution between the rich and the poor.*

The evolution of the IT market shows a drastic reduction of the costs implied (if compared with their performances): telephone terminals and televisions are now accessible for average villages in Africa, radio receivers are accessible to individuals; but computer or Internet terminals are already too expensive for even the poorest people even in the richest countries. The cost for telephone lines are however too high for mainly African users, and already cut them from the digital information sources.

INFORMATION TECHNOLOGY - ISSUES AND CHALLENGES

The rapid development and use of information and communication technologies are causing major repercussions on all aspects of the private and public life in all countries. This development is transforming the traditional ways of functioning of our contemporary societies and is providing new opportunities and challenges for all. This situation makes it important for developing countries to keep abreast of the new ethical, legal and societal issues and opportunities offered by the Information Society.

1. Societal and Psychological Challenges

- The analysis of impact of IT focuses both on structural changes and changes for the individual at work and on the role as citizen. The main humanistic focus is on possibilities and prerequisites, related to IT, for influencing one's own life conditions, for social belonging, for a meaningful life content, and for learning and developing oneself.
- The Information Gap: Looking at our society as a whole, there are noticeable inequalities or "gaps" in the distribution of information and information technology. For various reasons, some people appear

poised to garner greater benefits from technological advances than others. Observers have pointed to gaps that appear along several dimensions, including socio-economic status or income level, ethnic background, gender lines, or geographic gaps. Domestically, the geographic gap refers to a division between our urban metropolitan areas and rural regions. On an international level, it refers to the inequitable global distribution of technology and information. In other words, some nations have enormous technological prowess and capabilities, while other nations do not.

2. Ethical Issues

Ethical issues and concerns have always underscored the utilization, management and control of information. In the age of information, political and societal tensions will increasingly surface and coalesce, creating significant differences among groups within nations, as well as among nations. The quality of information content will be deliberated by the perceived haves and the have-nots. Who controls information will be a major issue for 21st century scholars and politicians.

There are many unique challenges we face in this age of information. They stem from the nature of information itself. Information forms the intellectual capital from which human beings craft their lives and secure dignity. However, the building of intellectual capital is vulnerable in many ways. The ethical issues involved are many and varied. However, it is helpful to focus on just four and leave it to ourselves the search for their answers:

Privacy: What information about one's self or one's associations must a person reveal to others, under what conditions and with what safeguards? What things can people keep to them and not be forced to reveal to others?

Accuracy: Who is responsible for the authenticity, fidelity and accuracy of information? Similarly, who is to be held accountable for errors in information and how is the injured party to be made whole?

Property: Who owns information? What are the just and fair prices for its exchange? Who owns the channels, especially the airways, through which information is transmitted? How should access to this scarce resource be allocated?

Accessibility: What information does a person or an organization have a right or a privilege to obtain, under what conditions and with what safeguards?

DISCUSSION

As information technology becomes increasingly indispensable for the development of society, the Developing World in particular can least afford to squander the vast opportunities presented by the ongoing information revolution. Faced with globalisation and the fact that IT has been proved to be the engine of development, the question is no longer if the IT is applicable to less developed regions, rather the critical question is how should the developing countries adopt the new information technologies in order to meet the economic development challenges?

Our rationale for participating in the information age is simple and strong: unless developing countries become full actors in the global information, they stand the risk of being excluded from the emerging global economy or suffering severe disadvantage in the competitiveness of their goods and services. Participating in the information age offers many opportunities for developing countries to "gain time on time"—to leapfrog over past development deficiencies into the future. A sizable number of developing countries have already made progress in their Internet links that have put them on the global connectivity roadmap.

Development can be seen as an increase of knowledge and skills and creative potentials that can be applied to improve the quality of life. Research shows that low levels of knowledge and inadequate innovative skills at lower, middle and higher levels have contributed to the continuous failures in African countries in all spheres. Information and knowledge are interrelated. Well-informed, knowledgeable and innovative citizens are causes for human centered development. Information technology facilitates the flow of knowledge in modern society. Observing the impact of information technology on economies, developing block cannot afford to persist in a state of information poverty. Information technology, if properly harnessed, will help bridge the information gap and will give impetus to faster development in virtually all sectors.

Information technology can improve economic performance, expand and sustain health services, promote education and research, enhance food security and gender balance in development, strengthen and diversify ties with trade partners, invigorate culture and tourism and alleviate man-made crises and natural disasters. In the area of human capital development, for instance, the systems of education in many Developing Countries suffer from serious shortcoming including low teacher-student ratios; limited availability of instructional material; and poor quality of education, related to inadequate funding and inefficient use of available resources.

Information technology offers a wide range of low-cost solutions, through for instance, distance education given its flexibility, and suitability for its widely scattered student bodies, particularly among rural schools where both teachers and students have no access to libraries, reading materials or communication with the outside world. Clearly, although ICT will not bring development overnight, it will certainly permit those who use it to be players in the world economy.

Information technology has created challenges and implicit solutions. The challenges involve adaptation of the technology to needs and the implied solutions are the possibilities of using the technology to attack the perennial problems of underdevelopment: poverty, low-productivity, inequality and environmental degradation. Though there is now growing recognition of the far-reaching impact of telecommunications and networking on the economies of Developing Countries, a number of problems restrict its diffusion through public institutions. It includes socio-economic problems crippling equal access to information and communication technologies, the resource at the disposal of governments are mostly directed to dealing with emergencies with little left for long-term investments in sectors that could trigger socio- economic development. Education, information and communication are some of the sectors that need immediate attention for development in Developing Countries.

The absence of an efficient telecommunication infrastructure though most of the countries have established Internet links, access is mostly restricted to the capital cities and it is extremely expensive mainly because of the inefficiency of telephone services. Those in rural areas remain electronically isolated. Ironically, as a result of the quantum leap in technology, the inadequate state of telecommunications in many of our countries can be transformed into a great advantage if properly managed. The fact that the telecommunications sector is lacking in both coverage and density means also that the country is not burdened with extensive networks, built on obsolete technology, they can push to the cutting edge by ensuring that new infrastructure is based on the latest technology. The inadequate policies and incompetence of telecommunications management in most countries blocks achievement of the right to communicate socio-economic development and universal access.

The high cost of computers and software represents another serious impediment. But experts in the field suggest that bare-bone computers and stripped-down software perfectly serviceable for Internet connections, word processing, and graphics can be built today for a price, which is many times lower than current prices. And one way to induce producers to comply with such requirements is 'bulk-purchasing', which should be feasible given the potential market size of Developing Countries.

Unfortunately, most developing countries do not have any explicit plans or policies on information technology. The acquisition of information technology and software is a result of isolated initiatives without preconceived strategies and policies with little coordination and planning. There is thus a pressing need to devise clear national and regional long-term strategies and policies that cover the acquisition of information technology, its enabling environment and its applications. The strategies should quantify the investment requirements of the countries and identify the required changes in institutional, training, legal and regulatory frameworks that will foster the development of the information societies in the region. Such strategies would also serve as an explicit recognition of the challenges of the information technology and as instruments for attracting and coordinating donor assistance in this domain.

Entering the information age is not only about getting connected to the Internet and receiving information from the rest of the world. Developing Countries should have the material that will travel in the opposite direction, if they are to benefit from the global information system. Thus, national institutions responsible for data collection and processing need to be strengthened and their information collection and dissemination structures modernized. The local content of information would need to be developed even at rural community levels in as many languages as necessary given the pluri-linguistic and multicultural nature of many Developing Countries. This will encourage participation and speed information diffusion to benefit the majority of people. Information exchanges among developing countries would need to be encouraged. Sub-regional information systems would need to be developed and improved to provide meaningful backing to national efforts in this area.

Equally important is the question of sustainability. It is pertinent, therefore, to invest in low-cost and locally adapted solutions, such as the use of solar driven appliances. It is also important to make the users pay, from the very beginning, for the services they receive.

Measures to expedite Developing Countries' entry into the global information system must also address factors constraining the development of the information infrastructure. Reviewing the regulatory frameworks is important to encourage private participation not only in cellular telephony, but also in the operations of the state-owned telecommunication enterprises. Removing legal and regulatory barriers to the use of information and telecommunication technologies would promote interest on the part of the private sector.

CONCLUSIONS

The promises of various socio-technical progresses of information technology (from the networking to the translation tools) is a chance for global sustainable development, if the society really wants equity and finds a way to solve the possible interest conflicts mentioned above. The ideal situation for sustainable development would be if anybody could speak to anybody using such a language that he/she can be sure to be understood, and take decisions knowing exactly which would be the effects of this decision on the present and future environment or societies.

Improving information technology is a way to improve the decision making process to be more reliable and less risky in its results, because it would accelerate the way of making reliable information from ground measurements, and allow more transparency in the modeling processes. Higher the communication capacity, higher the potential of humanity's sustainable development. Information technology gives powerful tools – and no solution - for sustainable development.

In the light of above discussion, it can be safely assumed that it is not merely a matter of identifying what kind of knowledge and expertise is required, in fact the important aspect is to understand the pros and cons associated with the options. This will enable us to beware of the issues and challenges ahead, and would enable us to prepare accordingly. This can be summed up by quoting Socrates:

"Knowledge: Knowing how to use a tool
Wisdom: Knowing how to best use knowledge"

This implies that knowledge without wisdom won't be enough and vice versa.

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BIOTECHNOLOGY FOR SUSTAINABLE DEVELOPMENT

*Anwar Nasim**

INTRODUCTION

The rate at which information is being generated has indeed no parallel in earlier human history. The ease with which one can access available information is just as impressive. It has been estimated that, whereas the total knowledge-pool will double in six to seven years, for life sciences such doubling time is estimated to be nearly three years. This new scenario provides an extremely rich and almost unmanageable store of data, but also poses the serious challenge for an effective and meaningful approach towards a focused discussion.

Thus, for scientists, academicians and policy makers, there is a dire need to realise that computers and other highly sophisticated devices have dramatically changed our ability to acquire, store and retrieve information. So, how do we cope with this explosion of knowledge? Internet, ISP's enable us to download enormous amounts of data in no time – that fact alone poses a serious challenge of how to manage, coordinate, analyse, draw conclusions, develop guidelines and then formulate effective strategies to cope with future challenges.

The information that is becoming available on the role of science and technology in economic development is certainly a very useful and rich source – the recent Human Development Report released by UNDP is one such example. The conclusions of this report could be summarised as follows:

Technology networks are transforming the traditional map of development, expanding people's horizons and creating the potential to realize, in a decade, progress that required generations in the past. Throughout history, technology has been a powerful tool for human development and poverty reduction. Today people all over the world have high hopes that new technologies, such as information and communications technology and biotechnology, will lead to healthier lives, greater social freedoms, improved knowledge and more productive livelihoods. The possibilities are great: new technologies and globalization are creating a network-age that is simultaneously changing the way technology is created, diffused and used. No country, at any level of development, can afford not to participate in these networks.

The report 2001 looks at how the advent of new technologies will affect developing countries and poor people. Technology is a tool, not just a reward, for development. Technological change can advance human development by improving human health, nutrition and knowledge and by enabling communication, participation and economic growth. Yet, many fear that new technologies may be of little use to the developing world, or that they might actually widen global inequalities. Indeed, without innovative public-policy, innovative technologies could become a source of exclusion and conflict, not a tool for progress. If any form of development is empowering in the 21st century, it is the acquisition of knowledge and the creation of technological capacity." The above statement is such that no one will disagree with its contents and the conclusions drawn. With all the above in mind, an effort is made to examine the role of biotechnology in achieving sustainable development.

It is in the light of the above realities that the topic for the present seminar will be discussed. Needless to state that, for the interested reader, there is absolutely no dearth of related reading material and only a few key references have been provided at the end.

One needs to start this discussion by precisely defining the two basic ingredients – Biotechnology and Sustainable Development. It is also important to emphasize that the different technologies being discussed in the present seminar, such as nuclear technology, nano-technology, information technology, again closely interact with each other to finally determine the ultimate impact on socio-economic scenario.

Outline History of Biotechnology

The term Biotechnology was coined in 1919 by Karl Ereky, a Hungarian engineer. He envisioned a

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biochemical age similar to the stone and iron age. Breaking the word biotechnology into root words we have: **"Bio"** the use of biological processes and **"Technology"** to solve problems or make useful products. A more appropriate definition of biotechnology, in the new sense of the word is: *"New" Biotechnology --- the use of cellular and molecular processes to solve problems or make products.* Thus, Biotechnology is broadly defined to include any technique that uses living organisms or parts of organisms to make or modify products, to improve plants or animals, or to develop micro-organisms for specific use. It ranges from traditional biotechnology to the most advanced modern biotechnology. Some of the more significant milestones are listed below (Table 1):

Table - 1

Date	Event
1750 B.C.	The Sumerians brew beer.
500 B.C.	The Chinese use moldy soybean curds as an antibiotic to treat boils.
250 B.C.	The Greeks practice crop rotation to maximize soil fertility.
1590 A.D	The microscope is invented by Janssen.
1663	Cells are first described by Hooke.
1675	Leeuwenhoek discovers bacteria.
1855	The *Escherichia coli* bacterium is discovered. It later becomes a major research, development and production tool for biotechnology. Pasteur begins working with yeast, eventually proving they are living organisms.
1863	Mendel, in his study of peas, discovers that traits were transmitted from parents to progeny by discrete, independent units, later called genes. His observations laid the groundwork for the field of genetics.
1869	Miescher discovers DNA in the sperm of trout.
1878	The first centrifuge is developed by Laval. The term "microbe" is first used.
1883	The first rabies vaccine is developed.
1914	Bacteria are used to treat sewage for the first time, in Manchester, England.
1919	The word "biotechnology" is first used by a Hungarian agricultural engineer.
1928	Fleming discovers penicillin, the first antibiotic.
1938	The term "molecular biology" is coined.
1941	The term "genetic engineering" is first used by a Danish microbiologist.
1943	Avery demonstrates that DNA is the "transforming factor" and is the material of genes.
1944	DNA is shown to be the material substance of the gene.
1953	Watson and Crick reveal the three-dimensional structure of DNA.
1970	Specific restriction nucleases are identified, opening the way for gene cloning.
1973	Cohen and Boyer perform the first successful recombinant DNA experiment, using bacterial genes.
1976	The tools of recombinant DNA are first applied to a human inherited disorder. Molecular hybridization is used for the prenatal diagnosis of alpha thalassemia. Yeast genes are expressed in E. coli bacteria.
1980	The U.S. Supreme Court, in the landmark case Diamond v. Chakrabarty, approves the principle of patenting genetically engineered life forms. The U.S. patent for gene cloning is awarded to Cohen and Boyer.
1981	The North Carolina Biotechnology Center is created by the state's General Assembly as the nation's first state-sponsored initiative to develop biotechnology. Thirty-five other states follow with biotechnology centers of various kinds. The first gene-synthesizing machines are developed.
1982	Humulin, Genentech's human insulin drug produced by genetically engineered bacteria for the treatment of diabetes, is the first biotech drug to be approved by the Food and Drug Administration.
1984	The DNA fingerprinting technique is developed. The first genetically engineered vaccine is developed. Chiron clones and sequences the entire genome of the HIV virus.
1986	The first field tests of genetically engineered plants (tobacco) are conducted. Ortho Biotech's Orthoclone OKT3, used to fight kidney transplant rejection, is approved as the first monoclonal antibody treatment. The first biotech-derived interferon drugs for the treatment of cancer - Biogen's Intron A and Genentech's Roferon A - are approved by the FDA. In 1988, the drugs are used to treat Kaposi's sarcoma, a complication of AIDS. The first genetically engineered human vaccine - Chiron's Recombivax HB - is approved for the prevention of hepatitis B.

1987	Humatrope is developed for treating human growth hormone deficiency. Advanced Genetic Sciences' Frostban, a genetically altered bacterium that inhibits frost formation on crop plants, is field tested on strawberry and potato plants in California, the first authorized outdoor tests of an engineered bacterium. Genentech's tissue plasminogen activator (tPA), sold as Activase, is approved as a treatment for heart attacks.
1988	Congress funds the Human Genome Project, a massive effort to map and sequence the human genetic code as well as the genomes of other species.
1993	Chiron's Betaseron is approved as the first treatment for multiple sclerosis in 20 years. The FDA declares that genetically engineered foods are "not inherently dangerous" and do not require special regulation. The Biotechnology Industry Organization (BIO) is created by merging two smaller trade associations.
1994	Genentech's Nutropin is approved for the treatment of growth hormone deficiency. The first breast cancer gene is discovered. Calgene's Flavr Savr tomato, engineered to resist rotting, is approved for sale.
1995	The first baboon-to-human bone marrow transplant is performed on an AIDS patient. The first full gene sequence of a living organism other than a virus is completed for the bacterium *Hemophilus influenzae.*
1996	Biogen's Avonex is approved for the treatment of multiple sclerosis. The company builds a $50 million plant in Research Triangle Park, N.C., to manufacture the recombinant interferon drug. Scottish scientists clone identical lambs from early embryonic sheep.
1998	University of Hawaii scientists clone three generations of mice from nuclei of adult ovarian cumulus cells. Embryonic stem cells can be used to regenerate tissue and create disorders mimicking diseases. The first complete animal genome for the elegans worm is sequenced. A rough draft of the human genome map is produced, showing the locations of more than 30,000 genes.
1999	The rising tide of public opinion in Europe brings biotech food into the spotlight. See our publication.
2000	A rough draft of the human genome is completed by Celera Genomics and the Human Genome Project. Pigs are the next animal cloned by researchers, hopefully to help produce organs for human transplant. "Golden Rice," modified to make vitamin A, promises to help third-world countries alleviate blindness.
2001	The sequence of the human genome is published in *Science* and *Nature*, making it possible for researchers all over the world to begin developing treatments.

Some 7000 years ago in Mesopotamia, people used bacteria to convert wine into vinegar. Sumerians and Babylonians were drinking beer by 6000 BC. Egyptians were baking bread by 4000 BC and wine was known in the near east by the time the Book of Genesis was written. Theophrastus – an ancient Greek who lived 2300 years ago---swore that broad beans left magic in the soil. In 1885, a French chemist Louis Pasteur suggested that some soil-organisms might be able to fix the atmospheric nitrogen into a form that plants could use as fertilizers.

The term “Classical biotechnology” can be used to describe the course of development that fermentation has taken since the ancient biotechnology period. Ethanol, acetic acid, butane and acetone were produced by the end of nineteenth century by open *microbial fermentation processes.* In the 1940s complicated engineering techniques were introduced into the mass cultivation of microorganisms to exclude contaminating microorganisms.

Modern Biotechnology

The latest biotechnology revolution began in the 1970s with the arrival of: Applied Genetics and Recombinant DNA technology. This genetic engineering had a profound impact on almost all areas of traditional biotechnology and further led to breakthroughs.

The major strength of biotechnology is its multidisciplinary nature and the extremely broad range of scientific approaches that it encompasses. This is graphically represented below Figure-1:

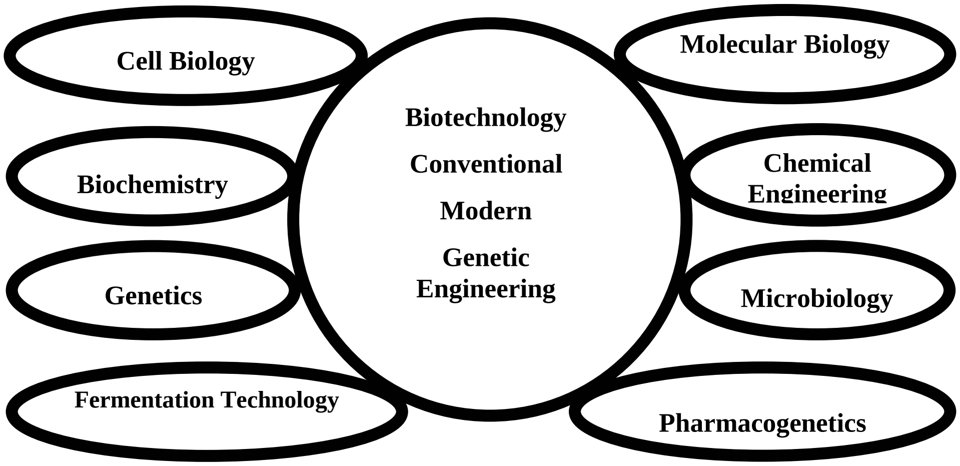

Figure-1

The same is true for the very large number of products that biotechnology can provide (as shown below) Figure-2.

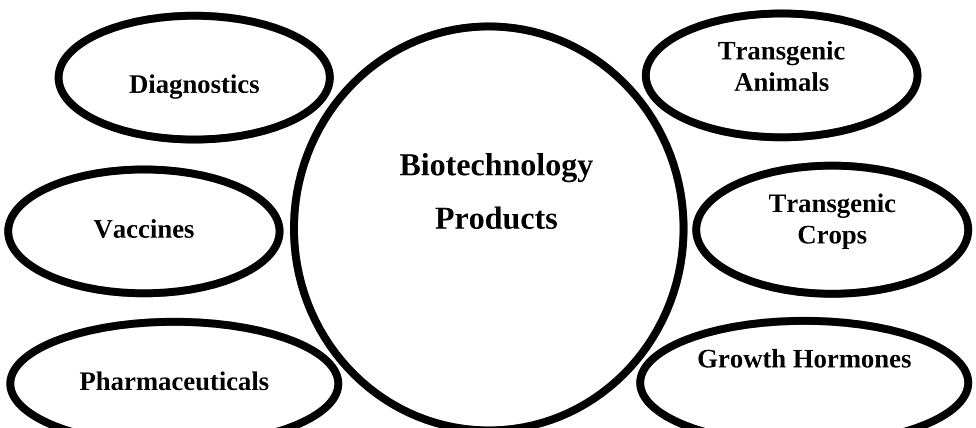

Figure-2

As a result of the above two aspects, biotechnology has become a pivotal tool for sustainable development in such diverse areas as Agriculture, Environment, Industry and Human Health. Biotechnology, the application of an explosion of biological knowledge, gives humankind the ability to alter the structure of life itself. Whether biotechnology proves to be a miracle or a menace depends on how it is used and controlled?
It is a combination of these two aspects i.e. the multidisciplinary nature and the wide range of products produced which now, using genetic modification make, it possible to apply all this know how to achieve the following. These are only a few examples.

Currently, we are using genetic modification to:

- Produce new and safer vaccines.
- Treat some genetic diseases.

- Provide new and better medicines.
- Increase crop-yields and decrease production-costs.
- Improve food nutritional value.
- Increase livestock productivity.
- Develop biodegradable plastics.
- Decrease water and air pollution.

Commercial biotechnology consists of an expanding range of interrelated techniques, procedures and processes for practical applications in the health care, agriculture, industrial and environment sectors. Commercialization of biotechnology ranges from research to products and services. These are powerful technologies, supported by complementary bioprocess-engineering, to help translate new discoveries of life-sciences into practical products and services. As such, biotechnology should also be seen as an integration of the new techniques emerging from modern biotechnology with the well-established approaches of traditional biotechnology, such as plant breeding, food fermentation and composting.

In view of time-constraints, it seems appropriate to illustrate the potential economic impact of biotechnology by using agriculture as an example.
Number of international organizations: IUCN (The World Conservation Union) UNEP (United Nations Environment Programme), WWF (World Wide Fund for Nature) jointly organized a seminar in 1991 which was later published as “Caring for the Earth, a Strategy for Sustainable Living”. Among the several definitions of sustainable development, the one given in ‘Caring for Earth’ is the most appropriate. It says, “*Improving the quality of human life, while living within the carrying capacity of supporting ecosystems”.*

Sustainable Development

Economic prosperity, development and, more so, sustainable development are complex issues, which are the end-result of a whole set of interacting factors. The concept of sustainable development was launched by the World Commission on Environment and Development in the report ‘Our Common Future’ in 1987, and reinforced by the UN Earth Summit in Rio de Janeiro (1992). The concept of sustainable development is based on the conviction that it should be possible to increase the basic standard of living of the world's growing population, without unnecessarily depleting our finite natural resources and further degrading the environment in which we live. Emerging biotechnologies, based on new scientific discoveries, offer novel approaches for striking a balance between developmental needs and environmental conservation. A wider diffusion of the technology is thus seen as the key to directing its positive impacts onto the world's society as a whole. Biotechnology is continuously and rapidly developing in an increasing number of sectors that improve the effectiveness of the way in which products and services are provided. However, the transfer and development of biotechnology, in an environmentally sound manner, requires a variety of conditions, including capital inputs that, in the case of many developing countries, are not readily available.

One of the important aspects of biotechnology is its role in the sustainable development of various sectors. Sustainability is fast becoming the corner stone of economy of many countries, both developed and developing. Such a development, in turn, depends upon the use of new technologies, innovations, entrepreneurship and utilization of inexhaustible supply of renewable resources. Biotechnology is one such technology, which has rapidly developed over the past few decades and has great potential for solving many problems pertaining to Agriculture, Industry, Environment and Health, which have direct relevance to sustainable development. These features and potentials of biotechnology have generated great interest among the developing countries, many of which have embarked on various programs in biotechnology at various levels.

In the majority of developing countries, agriculture is the mainstay of the economy. Any improvement in agricultural productivity directly helps in improvement of the economy. The role of new biotechnology in agriculture has been described as a precursor to another Green Revolution that would help eliminate the world’s hunger. The conventional methods of genetic improvement resulted in significant increase in grain production over the past few decades.

In addition, industrial processes based on biotechnology, are often economical as they consume less energy and use raw material more effectively. The largest contribution of biotechnology is in the pharmaceutical industry, where various drugs are being produced by genetically engineered microorganisms (GEMs). The best known examples are human insulin, interferon and growth hormones.

Transgenic Crops

The modern powerful techniques of gene-manipulation have now made it possible to move genes between different species. By using this approach, transgenic crops have been constructed. At present these include Maize, Rice, Cotton and Soybean. The steps involved in this process are graphically depicted in Figure-3.

TRADITIONAL PLANT BREEDING
DNA is a strand of genes, much like a strand of beads. Traditional plant breeding combines many genes at once.

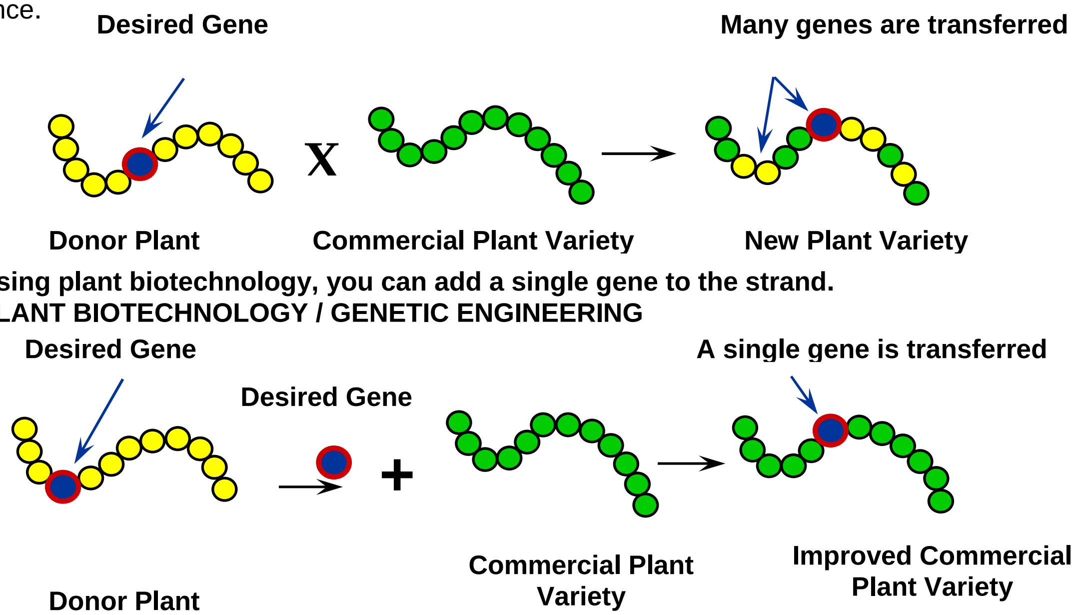

Figure-3

The global challenges that we presently face in the area of food-security are indeed frightening. At present, some 480 million people go hungry every day and at least 1.3 billion live on less then US$1 per day. If the world can't make progress against hunger and poverty by year 2025, there could be 4 billion people living on less than US$2 per day and more than 2 billion living in extreme poverty. Scientific research serves the cause of the poor and the hungry. At a time when science is moving at a spectacular pace, it is essential that the new and exciting possibilities for increased agricultural productivity and sustainable natural- resources management are realized in the developing countries. One promising approach is to have transgenic crops, showing increased yield and enhanced resistance to disease.

Table - 2: Global Area of Transgenic Crops, 1996 to 1999(million hectares/acres)

Year	**Hectares** (million)	**Acres** (million)
1996	1.7	4.3
1997	11	27.5
1998	27.8	69.5
1999	**39.9**	**98.6**

Increase of 44%, 12.1 million hectares or 29.1 million acres between 1998 and 1999.

In the light of the above table, one can briefly discuss the correlation between biotechnology and sustainable development in the following manner that sustainable development has become a priority for the world's policy makers. Among the broad range of technologies with the potential to reach the goal of sustainability, biotechnology could take an important place, especially in the fields of food-production, renewable raw-materials and energy, pollution- prevention and bioremediation. However, technical and economic problems still need to be solved. The environmental impact of biotechnological applications has to be very carefully examined, in the light of bio-safety guidelines developed by different national and international committees. It is really important to critically asses the risks and benefits, paying specific attention to the environmental impact of the release of any micro organisms or crops.

Any strategy has to be a guide rather than a prescription. The world thus needs a variety of sustainable societies, achieved by many different paths. Each nation and the communities living there must find their own specific solutions and develop extremely well-defined national strategies. All countries require appropriate infrastructures that permit them to acquire, absorb and develop technology, to manage it properly and systematically, and to build up local scientific and technological competence. The resultant ability of any country and of a developing country, in particular, to discern, choose and adapt an environmentally sound emerging biotechnology can serve as a measurement of sustainable self-reliance that will allow it to participate fully in worldwide efforts to achieve sustainable development. The creation of such enabling conditions poses new challenges that must be addressed, for developing countries to fully realize the potential benefits of biotechnology and minimize any possibly adverse socio-economic or environmental effects.

It is this ambition and commitment to acquire, sustain and establish enabling conditions which pose new challenges to the developing countries. Such crucial questions have to be aggressively addressed, before one can realistically expect to benefit from such frontier technologies, without in any way having to compromise with any deterioration of the environment.

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ROLE OF A MATERIALS-SCIENCE BASE IN SUSTAINABLE DEVELOPMENT

*Anjum Tauqir**

ABSTRACT

Materials are the backbone of technological development in a country. No industry, no machinery and no product can by-pass a thorough knowledge of the materials. The Metallurgy Division, KRL, is routinely involved in characterization of materials, and recommending best-suited alternate materials for different high-tech applications. With its state-of-the-art equipment and highly educated and trained manpower, the Division has a diversified experience in addressing problems encountered, not only in KRL, but also in state and private industries in Pakistan. The paper discusses our potential and experience to handle a wide spectrum of projects in the field of materials and the assistance this Division has rendered to the public and private industry in the country.

MATERIALS BASE

The Metallurgy Division of KRL caters for the materials-problems in our centrifuge and missile projects. The collaboration of the Metallurgy Division with public and private industry in the country is evolving. It is imperative that organizations capable of collaborating with local industry should discuss their potentials and disseminate information about their capabilities. The potential of the Division as a materials base is discussed in terms of the existing facilities and manpower. Its role to sustain industrial development can be judged by the activities of the Division, both within the organization and with the organizations in the vicinity.

EQUIPMENT

The division is equipped with state-of-the-art equipment, which deals with the following:

Metallography and Microscopy

Investigations on materials start form Metallography. The optical microscopy system is attached with a computerized image-analysis system, which quantifies the micro-structural features. If higher magnification is required, we go to electron microscopes. The scanning electron-microscope can accommodate a variety of samples, including fracture surfaces. In transmission and scanning transmission, we may go to magnifications up to one million times. The electron microscopes have an attached spectroscopy-system, to conduct chemical analysis of selected localized features.

Spectroscopy

The general chemical analysis of bulk samples is usually conducted by energy- dispersive spectroscopy, attached with scanning electron-microscope or emission spectroscopy. The concentration of trace elements is determined by using atomic absorption spectroscopy or inductively coupled plasma. The concentration of carbon/sulphur or dissolved gases is determined by using rapid determinators. It may be pointed out that the concentration of 4 atoms of hydrogen in one million atoms of matrix is sometimes not permissible in high-strength steels. The chemical analysis determines the elements present in the material and their concentrations, but does not discuss their arrangement which affects the mechanical properties of the material.

Crystallography and Texture

The arrangement of atoms in the material is determined by x-ray or electron diffraction. The most commonly used instrument is diffractometer, while Debye Sherrer camera is used for precision work. To determine the orientation of atomic planes in a single crystal, for example in wafers used in solar cells, Weisenburg Precision Camera is used. The texture goniometer is used for research purposes.

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To impart required structure to a material of given composition, the material is subjected to the required heat treatment cycle.

Heat Treatment

The laboratories are equipped with a variety of heat-treatment facilities. The process can be conducted in air and, for cleaner materials, in vacuum or in the presence of inert gases. Sometimes, heating in reactive gasses is needed to synthesize the required coatings on the surface of components. The heat-treatment furnaces are programmable and can ensure required temperatures and heating/cooling rates. The appropriate heat-treatment gives the required mechanical properties to the material, which can be confirmed by testing standard samples in the mechanical testing laboratory.

Mechanical Testing Laboratory

The facilities in mechanical testing include traditional macro-hardness testers, while micro-hardness testers determine hardness values of individual phases, surface layers/coatings or localized regions. The impact-testing facility determines toughness of the material at room, as well as cryogenic temperatures. The universal testing-system determines uni-axial properties of the material: these include tensile, compression, shear, three-point bend test, etc. Standard samples, components and intricate joints are routinely tested at room, cryogenic and elevated temperatures. The fracture-mechanics lab is involved in studying the crack-propagation behavior and fatigue properties. For aerospace materials, thermo-mechanical fatigue testing can be conducted. In addition to the above, the manpower is capable of designing and conducting dedicated tests, like the phenomenon of hydrogen embrittlement.

Coatings

The designer and user of materials today impose stringent conditions, which sometimes cannot be met by one material. A component, for example, is made from steel to impart required toughness and strength and is then coated to provide the required wear, corrosion or fatigue resistance. The steel component used in ammonia atmosphere in a local fertilizer-industry has a life of 2000 hours. After it was coated with TiN in our laboratory, the life is enhanced to more than 3 times this. The coating is only a fraction of a millimetre thin. Other cutting tools exhibit an increase in life from 3 to 10 times.

Corrosion

The group working in corrosion is conducting research, not only in aqueous corrosion, but also in gaseous phase, which is a requirement for the centrifuge- project where corrosive UF_6 gas is used. With Pakistan Navy, we have worked on a project to scan the waters of our shores in order to analyse the hazard of corrosion in our vessels.

Magnets

The magnets group is not only involved in studying magnetic materials but is also responsible for their production. Most of the equipment they are using is designed and developed within the Division itself.

Ceramics

This is a newly evolved group, which has developed quite a few critical components in a short time. The group is capable of manufacturing precision- components of high-density alumina.

MANPOWER

An obvious question would be the calibre and expertise of the manpower in the division. More than 30% of the technical personnel in Metallurgy Division are scientists and engineers. The Division has a number of Ph.D.s working in different fields of Metallurgy, Materials Science and Applied Physics.

In the wake of the financial crunch, it is getting increasingly difficult to acquire new state-of-the-art equipment for R & D in Pakistan. It may be pointed out here that, to keep equipment in running condition is more difficult, while the most difficult task is to use the equipment and generate useful results. Let us now discuss what are the activities of the manpower in our Metallurgy Division.

ACTIVITIES

In general, the activities of the Division are divided into three categories, and these are:

- Production related activities, which include heat treatment, synthesis of coatings on components and vacuum melting and casting.
- The Division provides services of chemical analysis, mechanical testing, failure-analysis of components, etc., to other divisions and also to other organizations in the vicinity.
- The ongoing R & D activities encompass projects of KRL's interest, collaborative work with researchers in other organizations, and basic research.

Topics in Research and Development

The topics of ongoing research include studies on Managing Steel from different aspects; these include:

- Effect of γ-phase on Gas Nitriding
- Formation of solid-state dendrites during heat-treatment in oxidizing atmosphere
- Growth and Texture of oxide film
- Stress Corrosion Cracking
- Effect of Over-load on life-extension
- Surface-hardening, using selective ageing
- Strain-hardening, using thermal cycling

The interest on other materials includes:

- Prolonged ageing of Al-Mg-Si alloys
- Development of Cr-Co-Mo , special steels and Cu-base alloys
- Boriding on Inconal
- Corrosion of special steels in HNO_3
- Synthesis of Tool steel on Mild Steel, using electron-beams and lasers
- Transformations in TiNi
- Recycling of Ni-Cr-Fe-Mo Dental material

The R & D projects include development of components, like IR sensors and turbine blades for missile projects.

Different equipments recently developed, or presently being developed includes:

- Atomization chamber to produce clean metallic powders.
- Vacuum Arc Double Electrode Remelting Furnace, to clean steels from dissolved gases and segregation.
- Magnetic Annealing Furnace, to process magnets.
- Thermo-magnetic Dilatometer
- B-H curve-tracer, operative at elevated/ cryogenic temperatures
- Wear-test machine
- Bend-test machine

Collaboration with other Organizations

The Metallurgy Division is collaborating with various organizations in the country and even outside Pakistan. These include educational institutes, R & D organizations and industries in public and private sector. Keeping in view the interest of participants in this Seminar, we will discuss development of a critical component from weapon-grade material in Pakistan, through collaborative work of KRL, PSM, HMC and HIT. The project is “Indigenous development of the first Pakistani 105 mm tank gun-barrel”.

Development of the 1st Pakistani 105 mm Tank Gun Barrel

The 105 mm barrels are deployed on T-59 tanks in Pakistan Army. The idea to locally produce 105 mm gun-barrel goes back to the times when Heavy Mechanical Complex (HMC), Taxila, acquired (quite sometime ago) complete facilities to forge and heat-treat the gun-barrel blanks. These include a 3150 - ton press, the biggest in the country even today, pit furnaces (probably the deepest in the country) and similar associated facilities. The major missing step in the complete indigenization was the facility to produce materials of high purity.

With the rehabilitation and modernization of Peoples Steel Mills (PSM), the problem could be addressed. The hierarchy at KRL decided to coordinate with PSM, HMC and HIT, to bring the theoretical possibility of local manufacture of the barrel into a reality. A team of KRL experts was involved throughout the production cycle and the subsequent testing of the barrel.

By any criterion, the barrel exhibited promising results. The accuracy, muzzle-velocity and wear-resistance are comparable to any standard. The life of the barrel was predicted, based on the wear data. The Pakistani barrel, with the grace of Allah, is second to none in its performance.

Collaboration with Pakistan Air Force

The interaction with Pakistan Air Force started in the 90’s, when repeated accidents of our aircrafts occurred. Since then, we have conducted numerous failure-studies and are working on development of critical components.

Collaboration with Pakistan Navy

The interaction with Pakistan Navy exists in different projects, which include sea- water analysis, development of composite-seal, made of bronze graphite, development of different components of sensitive nature, but the most noteworthy project was Sonar Hydrophones refurbishment.

POTENTIAL FOR SUSTAINABLE HIGH-TECHNOLOGY PROJECTS

The division has the potential to promote some mega-projects in the country. These include state-of-the-art Sonar laboratory for design and development of sonars according to our requirement. The other important field in which we can venture is the establishment of units to repair and develop components for high- tech aerospace applications.

In principle, the Metallurgy Division, KRL, foresees a broad potential of cooperation with other public and private-sector organizations in the country. There is sufficient potential for the enhancement of activities in the field of high-technology materials.

NEW TRENDS OF TECHNOLOGY COMMERCIALISATION - ROLE OF PCSIR

*Anwar ul Haq**
*Saeed Iqbal Zafar***

ABSTRACT

Pakistan Council of Scientific and Industrial Research (PCSIR) was established in 1953, with a view to support and develop the technological base of the country. This paper highlights the contributions of PCSIR and its experience in the field of commercialisation of technology. The new concept of technology business-incubators, being introduced in some countries to support industrialization of technologies in aided/subsidized environments, is briefly described. The first attempt to establish business incubators in Pakistan and its outcome is also presented.

BRIEF HISTORY

PCSIR had its birth two years after the independence of Pakistan, as the Department of Scientific and Industrial Research under the administrative control of the Ministry of Industries, Government of Pakistan, in 1949. In 1953, PCSIR was formally constituted as an autonomous body under the Societies' Registration Act XXI of 1860. Again, after twenty five years, in 1973, it was reorganized under The Pakistan Council of Scientific and Industrial Research Act (XXX of 1973) passed by the National Assembly, replacing the earlier structure. The organization is managed by a Governing Body and the Members of the Council are nominated by the Ministry of Science and Technology, so that a broad spectrum of views can be made available for an effective executive management of the objectives desired.

During the course of more than 47 years of its existence, PCSIR has made headway in many fields, which are of considerable national importance. Broad areas of achievements relate to water-decontamination technology, solar energy, fuel research, oils and fats, glass and ceramics, fabrication of pilot-plants, instrumentation and calibration, public health, leather technology, edible oils, industrial organics, and pharmaceuticals. The organization is now catering to R&D needs in the vital fields of minerals, metallurgy, food, health, agriculture, drinking water and energy.

The Objectives of PCSIR are summarized below:

- Systematic evaluation, development, value addition and utilization of the indigenous raw materials.

- Research and development work on problems that are being faced by the industrial sector, in order to adopt measures for the application and utilization of research- results.

- Indigenization of technical developments, through adaptation, modification and improvement of existing technologies appropriate to local conditions.

- To plan the establishment of new science-based and science-oriented industries, which would help in improving the export-potential/performance of the country, in providing employment-opportunities at minimum cost, and in creating a self-reliant and self-sustaining industrial base.

MAIN RESEARCH FACILITIES AVAILABLE

Human resource development and the main research facilities of PCSIR are summarized below:

- Pak-Swiss Training Centres, for technicians training and the award of technical diplomas, at Karachi and Quetta.
- Institute of Industrial Electronics Engineering, Karachi (a degree awarding institute).

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- Four multifunctional research-laboratories, located at Karachi, Lahore, Peshawar and Quetta.
- Fuel Research Centre and Leather Research Centre, both at Karachi.
- Solar Energy Research Centre at Jamshoro, Hyderabad.
- National Physical and Standards Laboratory at Islamabad.
- Scientific Information Centre at Karachi.

ACHIEVEMENTS

PCSIR is the premier research and development (R&D) organization of the country. It has competent staff of 600 scientists, including 100 Ph.Ds, about 70 engineers and a total manpower of 1,400 employees engaged in R&D activities. Table 1 presents the achievements of PCSIR in the field of human-resource development, technology development and its commercialisation. It is appropriate to mention that 156 Ph.D. theses were supervised by its scientists/engineers during the pursuit of their applied investigations at various PCSIR laboratories. The work was duly recognized through the award of degrees by national universities. Furthermore, its Pakistan Swiss Training Centres at Karachi and Quetta have trained about 1,150 technicians in the fields of instrumentation technology, optical technology, and dies-and-mould technologies. The Institute of Industrial Electronics Engineering, Karachi, has so far produced approximately 270 graduate-engineers, who received their degrees from NED Engineering University. It will not be out of place to mention that training in the above mentioned technologies/fields is only available at these PCSIR institutions.

Ever since its inception, PCSIR has developed about 647 technological processes and has obtained about 360 patents, besides publishing about 3,570 pure and applied research papers in national and international scientific journals of repute. To assess the impact of R&D conducted by PCSIR on the economy of the country, a survey was conducted in 1990. This showed that upto 1990, PCSIR had sold 367 processes, out of which 242 were commercialised (39 out of which were resold by the original buyers). Moreover, 150 processes were still in production upto 1990 (Table-1), which resulted in foreign-exchange savings of Rs.7 billion to the exchequer. The annual turnover of processes, according to a conservative estimate, was Rs.612 million, whereas PCSIR budget in 1990 was Rs.142 million (present budget is Rs.279 million). Thus, PCSIR is significantly contributing in the economic development of the country, in spite of serious manpower and financial constraints faced by PCSIR over several decades. The main reason for below-par level of commercialisation of PCSIR technologies is the lack of a law for the protection of intellectual property rights in the country.

WHAT TO DO NOW?

Many developing countries are encouraging investment in the industrial sector for their economic growth. In order that efforts of these countries may succeed, a thrust towards science-based technology development is the single most significant element required. The usual support needed by techno-entrepreneurs in these countries is a reliable access to intellectual property and technical expertise. The technology-based businesses, particularly in the early development phase, need access to good infrastructure, management and technical knowledge. Such an opportunity is being provided through the establishment of “Technology Business Incubators (TBIs)” in a large number of developing countries, such as China, Italy, Poland, Turkey, Nigeria, Mexico, India and Indonesia, to mention only a few. A TBI is a controlled work-environment designed to role-model the development and commercialisation of technologies, through successful implementation of the TBI concept. During a 10-year period, ending 1999, China had established 110 TBIs having an incubation area of about 2 million sq mtrs and over five thousand enterprises. Out of these enterprises, about two thousand graduated successfully and created nearly one hundred thousand job- opportunities. Pakistan now stands to gain a lot from the Chinese experience, through the Science & Technology bilateral protocol.

Recent studies indicate that new and emerging enterprises have developed more successfully when operating in proximity to universities, R&D institutions, trade and networks of technology, outsourcing through the internet. PCSIR, due to vast experience of interacting with these elements, is most suited for initiating the process of TBI development in the country. Some of the outstanding merits of PCSIR in this regard are given in the following paras.

Table - 1: Achievements of PCSIR (1953 to 2000)

Sr. No.	Name of Field	Number of Beneficiaries
(A)	**Human Resource Development:**	
1.	Supervisory guidance & laboratory facilities provided to Ph.D. students:	156
2.	Engineers produced B.E.(Industrial Electronics Engineering):	272
3	Diploma of Associate Engineers: (i) Instrument Technology (ii) Dies & Moulds Technology (iii) Optical Technology	 878 241 30 Total: 1149
4.	Post Diploma Certificate in Industrial Technology:	224
5.	Short Courses Certificates awarded to in-service Engineers/Technicians:	1300
(B)	**Scientific Achievements upto 2000:**	
6.	Research Publications (approx.):	3750
7.	Patents Obtained (including 29 foreign patents):	360
8.	Processes leased out:	647
(C)	**Technological Achievements upto 1990:**	
9.	Processes sold:	367
10.	Processes Commercialised:	242
11.	Processes in Production:	150
12.	Re-sold Processes (by Purchaser):	39
13.	Saving in Foreign Exchange:	Rs.7.00 Billion
14.	Annual Turn-over:	Rs.612 Million
15.	PCSIR's Budget (1989-90):	Rs.142 Million

The principal objective of PCSIR is to promote the overall technological development of the country. As such, it is the premier national R&D organization, duly chartered to do industrial research. Its scientists and technologists, within this context, as mentioned earlier, have contributed significantly. PCSIR has four multidiscipline and five mono-discipline laboratories, which are regularly visited by SMEs numbering over three thousand ad-hoc technical jobs annually. PCSIR laboratories are located close to universities and in close proximity to major industrial estates in the country.

Establishment of TBIs at various campuses of PCSIR, in view of the above- stated factors, meets the basic criteria of success of TBIs. It is, therefore, proposed that, in the first instance, TBIs may be set up at the Karachi and Lahore Laboratories Complex, where sufficient land is also available for initiating such a programme. These TBIs, on completion, will each have a covered area of 2,500 sq mtrs, with about 20 resident companies, 150 workers, and the expected sale of about Rs. 50 million at the end of their third year of existence. By the third year, these TBIs are expected to graduate 15 enterprises. The facility will be fully equipped to extend the following services:

- Meeting Places: conference rooms, assembly-recreational hall.
- Technical Exchange: product-display rooms, consultation rooms.
- Personnel Resourcing: training rooms, computer/audio-visual rooms.
- Information Services: technical and market information, database.
- Business Support: testing, analysis, measurement devices, teleconferencing.
- Technical Support: provision of intellectual-property link-up with universities/technical institutes.
- Technical Consultancy: panel of technical experts.
- Law Services: patent information, law consultants.
- Financial Support: banks, risk-venture companies.
- Technical Incubation: laboratories, pilot operation for technology testing.

An additional likely benefit of setting up of the proposed TBIs at PCSIR Laboratories is that, with the above mentioned facilities and services, researchers and inventors may become attracted to the setting up of their own high-tech companies for transferring their scientific results into products. The proposed TBI complex will thus become a “model middle organization” between research and manufacturing.

BUSINESS INCUBATORS IN PAKISTAN

Askari Commercial Enterprise (ACE), a subsidiary of Army Welfare Trust, started rehabilitation of 500-600 army officers per year, who take premature retirement from the services. They started this project in 1997, with the help of UNIDO and Experts Advisory Cell, Ministry of Industries, Government of Pakistan, Islamabad.

ACE runs reorientation courses of six weeks to provide 25-30 candidates, with the basic knowledge and mind set for their venture. So far, they have managed13 courses. From these participants, they select potential candidates to provide subsidized logistic support, such as office with furniture at a monthly rent of Rs.2500-3000, free guidance throughout their stay, and services of supporting staff, telephone, fax, photocopy, e-mail at no-profit-no-loss basis. Such candidates are allowed to stay upto 12-18 months and then they are encouraged to move into their own premises. So far, they have 78% success rate. It may be noted, however, that the ACE Business Incubator is not a technology-based incubator. Therefore, the proposal of setting up of TBIs at the PCSIR laboratories will, infact, be the first initiative of its kind in Pakistan.

CONCLUSIONS

For the success of technological development in the country, the concept of Technology Business Incubators should be given a serious thought and implemented as proposed above, as soon as possible.

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FINANCING TECHNOLOGY TRANSFER & DEVELOPMENT

*S.M. Junaid Zaidi**
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INTRODUCTION

At the dawn of the new millennium, new technologies are pushing the horizons of economic development to unprecedented limits. Never before has the development-process been so much influenced and driven by technology. Never before has the socio-economic development of nations been so dependent on access to technological advancement. Equally, never before has the need for monitoring current patterns of production and consumption been so pressing, to ensure achievement of sustainable development.

Access to sound technologies is essential for sustainable development. The developing countries' need for access to technologies is great; however the flows are subject to international transfer of technology constraints and the investment-decisions are influenced by the procurement-criteria of multilateral institutions and international lenders or more precisely "tied-aid" compulsions. The developing country initiatives of employing local component or to disassemble the imported technology have to be compromised, in the wake of their weak bargaining position.

The consequences of "tied-aid" go beyond the distortion of technology-choice. It inhibits the development of domestic capacity in selecting technology – the technology-choice becomes a matter of finding the biggest subsidy, rather than the most appropriate technology! It can crowd out good technologies and viable business models. It also acts to prevent private financial institutions from becoming involved in supporting technology-transfer and developing appropriate expertise.

Introduction of a new technology into a country essentially requires investment, as does the diffusion of existing technologies within a country. Technology-adaptation may also require substantial investments in design and/or production. Financing is also often required (and particularly difficult to obtain) in the early (developmental) phases of a technology-transfer project or business. Without financing, very little technology investment or transfer takes place, but the provision of financing depends upon those who have financial resources--whether multilateral institutions, governments or the private sector.

OPTIONS FOR FINANCING OF TECHNOLOGY

Many imported and indigenous technologies require change and innovation in the relevant institutions to support their transfer, such as devising new partnerships, new financing mechanisms, new channels for information distribution and new models for participation. Moreover, slow diffusion of imported technologies, together with the consideration of cost and availability of finance, suggest that there is potential for innovation to help support and accelerate the adaptation of imported technology. Certain types of finance appear to offer particular potential for funding transfer of technology, although they may require adaptation to the specific issue.

The development of indigenous technology and adaptation of the imported one requires its dovetailing with the business---commerce. Specifically, this can include development of the right policy-mix, direct support for investment in appropriate technologies, or support for project-preparation and development. The required measures further include policies and programmes to encourage public and private technology-transfer, introducing regulatory measures, subsidies and tax-policies as well as appropriate mechanisms for improved access and transfer of relevant technologies. Also, it is recognized that adapting assistance to local needs requires establishment of working relationships among various external and domestic actors involved and it is clear that coordination under the leadership of the host-country administration is a key to success.

A number of possible options and mechanisms for financing technology-transfer and development are shown in Figure - 1. It is important to understand that the host-country administration is essentially an ensemble of legal, economic and political, or more precisely macroeconomic and geo-political

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environment, surrounding technology transfer. Impediments to technology transfer and development, resulting from such conditions, might inhabit the vitality and effectiveness of one or the other mechanism in any particular set of conditions. Such impediments include lack of access to capital, a poorly developed banking-sector, lack of availability of long-term capital, high or uncertain inflation or interest rates, distorted (rather than marginal) cost of inputs, skewed import duties, instability of tax and tariff policies, investment risk (real and perceived), etc.

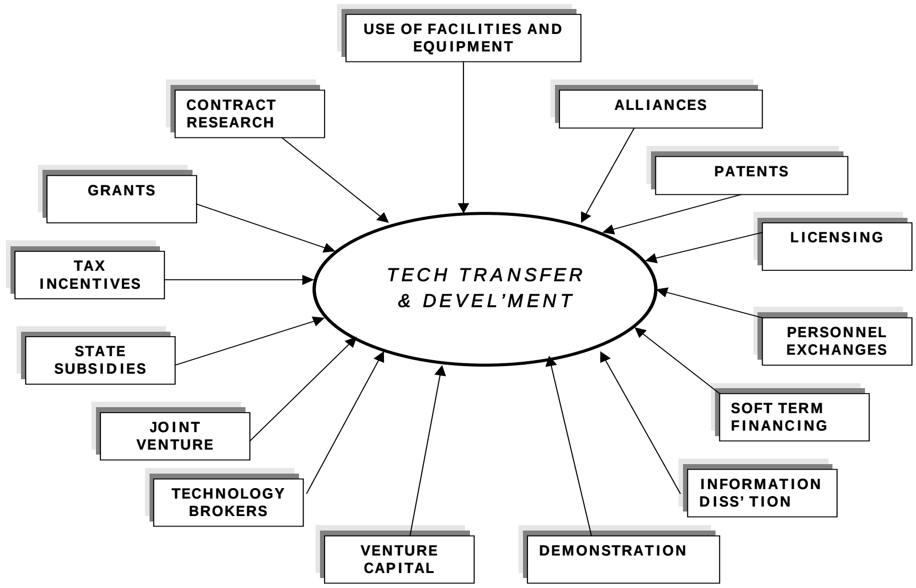

Figure – 1: Financing Technology: Options & Mechanisms

DIVERSITY IN FINANCING PERSPECTIVES

Investment finance for transfer and development of technology essentially comes either from public sector, private sector, a combination of the two, or from multilateral institutions. Financing perspectives differ enormously, not only according to the project, technology and business, but also according to the investor. Emanating from each one of these perspectives, the financing possibilities differ radically, one from the other--and each contains enormous diversity in itself.

Public finance has traditionally had a crucial role in supporting transfer and development of technology. Public finance has a role different than private finance, which can further vary by type and sector of investment. For example, it is more important for long-term and infrastructure investments. Traditionally governments, as well as their role in social infrastructure (education, health), have dominated investment in physical infrastructure and large-scale technology development. Thus there appears substantial merit in the public sector finding ways to support and encourage technology transfer and development. The advantages of public-sector finance may be offset by assistance in the form of tied aid, which can be detrimental to the long-term prospects for indigenous technology-development, through preventing the establishment of the institutions which support technology choice, financing, operation and management.

In recent decades, however, there has been increasing interest in opening public infrastructure development to the private sector, for example, by privatising state-owned companies, opening markets to competition and awarding projects on Build-Operate-Transfer mode of financing. Through large-scale investments by private sector, both in the physical and social infrastructure sector, private-sector finance is increasingly becoming important in offering prospects for national as well as international diffusion of technology. More importantly, through suitable incentives and innovative models, the relationship between public and private finance is becoming particularly important in the context of technology transfer and development.

The choice between different financing routes is determined by many factors. One major issue regarding the effective transfer of technologies is the fact that foreign investment tends to be institutionally divorced from host country objectives (supporting self reliance, sustainable development, capacity building, etc.) that have a huge influence on technology-choice and the intended national objectives.

Notwithstanding the mutually complimentary roles envisaged for the public and private sectors, it is noteworthy to recollect that private sector is extremely conscious about the cost of inputs. It expects relatively high rates-of-return and does not often monetise externalities. Instilling private support for technology-transfer invariably requires financial innovations and emphasis on different forms of finance, such as micro-credit, leasing, venture capital and special-purpose funds.

While a number of financing options like leasing, micro-credit, joint ventures, etc., have been in use for a long time and discussion on their merits and de-merits is beyond the scope of this paper, 'venture capital' is discussed for a brief retrospective.

VENTURE CAPITAL

Venture capital is particularly relevant to the development and transfer of new technologies. Venture capitalists are prepared to back risky investments to seek high returns and usually invest in small companies, such as those that have developed new technology, and/or have difficulties raising capital from other investors. Venture-capitalists have a relatively long-term focus, aiming to hold companies for several years before selling them, and have a more active approach than most other types of investors, in terms of participating in management of the company. This means that they can play an active role in supporting technology-transfer, if it forms part of the business-development plans of their investee companies. Venture capital has grown recently in the developed world, but less so in the developing countries, the reason being that the relatively high-risk environments in developing countries make the investors shy away from embarking upon technologies whose technical or market credibility is yet to be established.

One major impediment in establishing venture capital funds had been the absence of a favourable legal and regulatory framework, within which such funds operate. An example from Pakistan is relevant, where efforts had been afoot to set-up Technology Venture Capital Fund (TVCF) under the auspices of the National Technology Policy announced in 1993. The proposed TVCF, being a public unlisted company, was at disadvantage in terms of taxation under the draft-rules being framed by the Securities and Exchange Commission of Pakistan. After protracted follow-up, the tax authorities did accede to the proposed seven-year tax exemption, but have yet not agreed to exemption from minimum tax and from deduction of tax at source.

Venture capital is predominantly relevant to private-sector investments. It requires a relatively sophisticated financial infrastructure. However, venture capital has largely been focused on high-return sectors, such as computer software and biotechnology, and empirical evidence suggests that a relatively small amount of finance has gone into traditional sectors such as agriculture, manufacturing, industry, services, etc. Such sectors still form the backbone of economies in the developing countries but, due to a host of internal and external factors, have had a very mixed track-record in delivering returns to investors. Nevertheless, financing is required in these sectors for maintaining and sustaining the competitiveness of the developing economies, with ever- expanding markets for existing products and technologies.

PROPOSAL FOR CREATION OF TECHNOLOGY TRANSFER (TT) & DEVELOPMENT FUND (DF)

Notwithstanding the importance of venture capital funds in promoting new and emerging technologies for vertical transfer, the developing countries aptly aspire for horizontal transfer of technology. A preferred way to communicate with the private-sector is through suggesting mechanisms, which, on the one hand, provide financial incentives to the private sector and, on the other hand, discipline them to meet the broader national objectives. Overt and express incentives to motivate the private sector contribute in the horizontal transfer of technology.

Recognizing that technology transfer and development is the key to sustainable development, efforts are needed simultaneously for indigenization of the imported and up-gradation of the local technologies. Accordingly, establishment of a Technology Transfer and Development Fund (the 'TT & DF' and 'Fund' used interchangeably) is proposed with the objective of facilitating technology transfer and development for fostering sustainable development. This is in line with the developing countries' aspirations for increasing self-reliance, to demonstrate the possibilities of public-private partnerships, and to insinuate a "learning-by-doing" opportunity for the local industry.

The Fund will institute lending programmes, with more favourable terms than in ordinary lending for businesses. This will help in reducing the input costs of one key constituent i.e. finance. The Fund will be available to the projects with clearly defined and well-articulated program, along with agreed milestones to promote technology transfer and development.

Besides funding on concessional terms, the Fund will provide a forum for appropriate networking, information gathering and sharing experiences. It will help in lobbying for regulatory changes and encouraging investment. The TT & DF will further be focused on mobilising and multiplying additional financial resources and assisting in the improvement of policy-frameworks, through long-term commitments to capacity building.

OPERATIONS: HOW DOES THE TT & DF WORK?

COMSATS member countries and multilateral institutions will contribute in the TT & DF and the Fund resources will be used to promote indigenization of technology. The TT & DF will provide concessional finances (initially as loans and subsequently through equity-investments as well), management-support and information about technologies to the probable investors and entrepreneurs.

A schematic organization of TT & DF is shown in Fig. 2. The TT & DF will strive to engage constructively all interested parties in its development and operations. In this regard, strategic guidance will be sought from representatives of member countries, multilateral institutions, participating entities and business community, while remaining sensitive to the mission and objectives of the Fund.

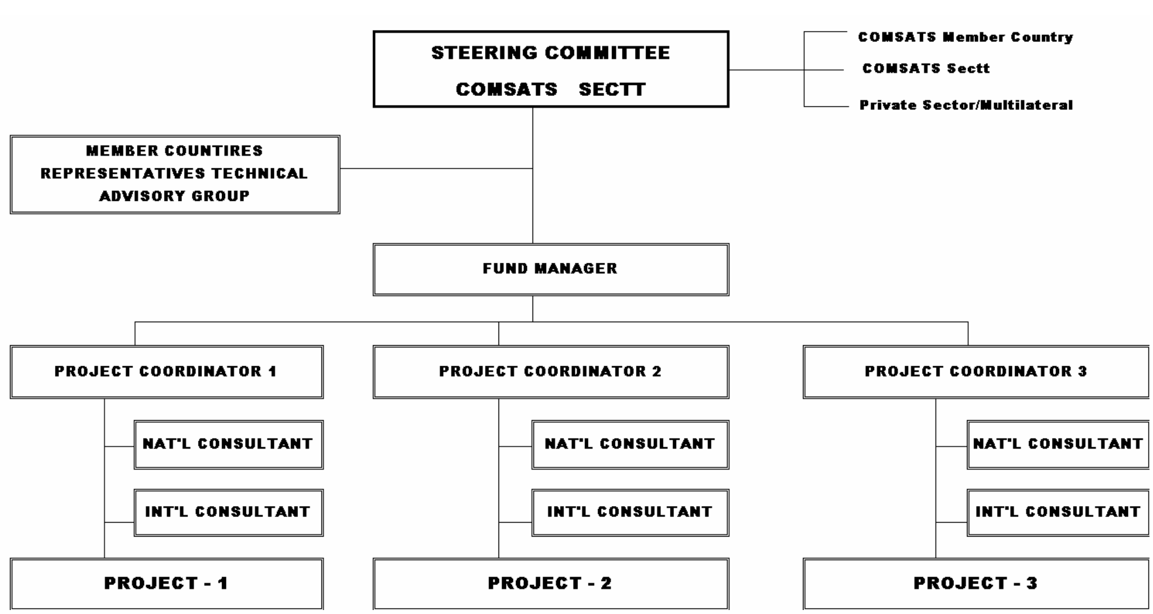

Figure - 2: Organizational Structure of TT & DF

BENEFITS OF TT & DF

The TT & DF will promote technology transfer and development, through a series of projects in member countries. Following a two to three-year pilot phase, the TT & DF will be evaluated, to devise the future operational strategy and subsequent operational programmes for promoting the objectives of the Fund. A significant aim of the programmes will be to catalyse sustainable development through creating vendor-industry in selected areas, remaining attuned to safeguarding the environment and enabling the private sector to transfer technologies and help upgrade human resources.

The benefits thus include capacity-building through technology acquisition, skill-development, and evolution of local policies and institutions to support the technology-transfer process, through market intermediation, matching technologies with applications, brokering partnerships, facilitating negotiations and devising financing-packages.

Replication or "indirect" effects likely to result from creation and operation of such Fund include:

- Project designs; through demonstrations,
- Resource mobilization,
- Improved regulatory frameworks and standards,
- Augmenting technical capacity,
- Devising new institutional models, and
- Encouraging stakeholder dialogues,

PROJECT PIPELINE: WHAT KIND OF PROJECTS DOES THE TT & DF FUND?

The TT & DF will be guided to achieve a balanced portfolio, both geographically and technologically. It is intended that the Fund will co-finance projects in small and medium enterprises (industry and manufacturing), renewable energy and, more importantly, in Information Technology. Major emphasis will be placed on projects, which have a great potential for replication and for local adaptation at reasonable costs.

The TT & DF will act directly, as well as through established intermediaries such as other similar investment funds, trade and commerce (business) organizations, large commercial banks, etc., to build capacity for developing economies to facilitate high-quality, attractively packaged, technology transactions.

The Fund, while acting as a financial mechanism, will facilitate firms to implement carefully planned initiatives for technology-transfer and development. Such initiatives would include training of staff, to learn newer skills and enhance productivity, help establish vendor-industry, transplant and adapt organizational work-setting to suit host country conditions, etc. This innovative and inclusive approach is likely to increase the opportunities for member governments (of COMSATS) to serve, *inter-alia*, their intended mandate vis-à-vis promoting sustainable development through facilitating technology-transfer and development programs.

SCOPE OF SERVICES

The TT & DF will provide:

- *Concessional Loans and Grants:* The Fund will initially provide finances as loans on concessional rates; subsequently the Fund will also make equity-investments. Grants will also be provided for arranging inter-industry trainings, in line with Fund objectives.

- *Business Advocacy:* Will serve as an advocacy focal point for interested entrepreneurs and business firms, to assist them to get help from intermediaries (e.g. SMEDA in Pakistan) throughout the COMSATS member countries.

- *Business Development Support:* Will provide a review of a company's current business-position, offering helpful insight in the areas of new opportunities, strategic planning and marketing assessments. Referrals to other state and federal organizations, for any additional information or assistance, will be provided to the interested companies and individuals.

- *Guidance:* Will offer guidance and direction to business firms and entrepreneurs, assisting them to better align their capabilities, to conform to the industry's requirements. This support will be provided via workshops, conferences, meetings, on-site visits and individual assessment of company's capabilities.

SIMILAR INITIATIVES

There are successful examples of special-purpose funds promoting their respective intended objectives and generally helping in resource mobilization. Examples include Global Environment Facility (GEF) by UN, Pakistan Energy Sector Development Fund (PSEDF) by the Government of Pakistan, World Bank, JEXIM, etc., and Prototype Carbon Fund (PCF) by the World Bank and GEF, UN, etc.

The GEF has provided support to projects to the tune of nearly US$ 2.7 billion and has been successful in leveraging more than US$ 7.0 billion (2000). Similarly, the PSEDF has been successful in mobilizing resources to the tune of US$ 5.0 billion (2000), through a contribution of nearly US$ 845 million.

Experiments like GEF have been instrumental in innovating and showing leadership in finance related to the environment. There are examples, as well, where some banks[*], like Poland Environment Bank, have also been active in working with smaller businesses to improve their environmental impact, often with a focus on energy-efficiency, through providing advice and information. In doing this, they intend to improve the credit-standing of their clients, as well as secure general environmental benefits.

EPILOGUE

The enunciation and operation of TT & DF will act as a prototype of a tangible effort in promoting technology-transfer and development for capacity-building, industrial resurgence and building confidence in the local capabilities. Although, small in proportion to the overall financial market, it would provide a very useful pathfinder role, in promoting and developing new concepts and ideas.

Care has to be exercised, accordingly, in understanding that TT & DF should not be seen as a leading source for facilitating technology-transfer and development; rather, it be seen as an administrative alternative to assist the developing countries in implementing their commitments to achieve self-reliance and sustainable development.

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[*] An example of a successful green financial institution is the Polish Environmental Protection Bank. Established in the early 1990s, it has received substantial equity investments from the Polish National Fund for Environmental Protection, strategic investors and from the private sector. The Fund has, in turn, instituted lending programmes with more favourable terms than in ordinary lending for businesses, seeking to reduce their environmental impact.

THE CONTRIBUTION OF SIMPLE AGRO-PROCESSING INDUSTRIES

*Sheila N. Yakwezi**

INTRODUCTION

The development of agro-processing industries in developing countries has been in many cases been associated with the production of export commodities. Modern processing facilities have been established as a consequence of this. Traditional methods may not be able to compete with the modern technologies that are replacing them. The topic of local and indigenous knowledge may play a particularly important role in the food sector of developing agro-industries.

Various economic conditions, such as fast urbanization as well as change in consumer habits, have to be met by agro-industrial development in developing countries. Processing technologies to be considered may include harvest, storage, and conservation, transport, processing of primary products, as well as recycling technologies. However, specific environmental conditions in developing countries may present particular challenges to the development and application of these technologies.

The progress will depend on the development of innovative products for the local markets, such as processing technologies for micro, small and medium sized enterprises (SMEs) in DCs, which may give them an opportunity to achieve the accepted standards. This paper outlines how simple processing activities could achieve this by studying the examples of value-added meat, together with cassava. In addition, how the economic landscape of a rural village could be improved by such a venture.

BACKGROUND

Uganda is a country in East Africa lying astride the equator. The Sudan to the north, Kenya to the east borders it, Tanzania and Rwanda border the country to the south and the Democratic Republic of Congo to the west. Uganda consists mainly of a high plateau, rising to mountains, as well as a considerable portion of area covered by lakes and rivers.

Uganda covers an area of 236,860 km^2, with a land area of 19,965,000 ha, of which 34.1% (68000,000ha) is arable and under permanent crops, while 9% (1,800,000 ha) is under permanent pasture (FAO, 1995).

Uganda is an agricultural country, with a human population of 21,300,000 having a fertility-rate of 3%, this rapidly growing population imposes a number of challenges in the provision of food. About 85% of this population are rural and engaged in agriculture. A problem associated with this kind of population is the limited nature of economic activities in the rural areas. Agricultural practices are mixed, with the majority at subsistence level.

MEAT AND MEAT-PROCESSING

Meat Production in Uganda

In Uganda, Livestock production consists of keeping of cattle, goats, sheep, pigs and poultry. The animal management system practiced is largely based on a communal grazing and tethering of indigenous livestock. Zero grazing of exotic breeds of cattle and their crosses is also practised.

Livestock contributes about 15% of agriculture production. Following the decline in cattle-production in Uganda from almost 8 million in 1970 to about 3.9 million in the 1980s, there has been a steady recovery of the national; herd. Between 1988-1998, the annual average meat production was (106.8 thousand tons), of which 64.8%was beef, 21% goat and mutton, pork 6 % and chicken was 8.2%. In 1984, total meat consumption was 800 thousand tons, while in 1992-1993, per capita consumption of meat was only 5.6 kg.

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Animal-Rearing Methods in Uganda

The cattle are mainly reared on rangelands which occupy about 84,000 km^2 extending from Moroto and Kotido in the north east, through central Uganda, to south west of Mubende, Masaka, Rakai and Mbarara.

The main livestock production systems include:

a. *Extensive Traditional*: The indigenous breeds are mainly kept under extensive traditional production systems. These include the East African shorthorn and the zebu. The indigenous breeds have been imported from Kenya and Sudan. Indigenous animals are hardy and adapted to the local environment.

b. *Intensive Commercial Systems* such as beef ranching on private and government farms, and zero grazing, but this constitutes less than 5% of the total production.

The exotic breeds of cattle include the Aberdeen Angus for beef shorthorn. The dual-purpose breeds are mainly Friesian and Red Poll.

Constraints to Meat Production

A number of problems are usually faced by the livestock farmer and some of these include:

- Poor Access to Markets: this may be due to expensive, poor, or even lack of, transport mainly due to the poor road-systems in the villages. The market may usually be a long way from the farm and, therefore, this may increase the transport costs.
- Low Purchasing Power of the Consumer: the consumers are not willing to pay the required price, either because they cannot afford, or they are willing to bargain elsewhere for lower price-ranges. This may create a problem for the farmer as he/she may have to sell at a very low and unprofitable price, especially if it is a distress sale. This is especially true during dry seasons, when the holding capacity of the farms is low.
- Disease: farmers at the grass-root level may not have enough money to buy the chemicals needed to treat disease causing organisms, such as ticks. Usually farmers may look at disease-reducing mechanisms as an unnecessary expenditure. This has an adverse effect on the quality of meat and its by-products.

Possible solutions to overcome these constraints and increase productivity

- Proper Infrastructure: this may include construction of proper roads within the village area. If there is improvement, then there will be better access to the market by the livestock-farmers. This problem can assume great urgency if livestock processing is carried out in the rural areas.
- Establish a Grading System: this will partly solve the problem of the purchasing power. The price to be paid should depend on a number of factors, such as the size, age, breed, weight of the animal.

Livestock Products Marketed

The livestock are marketed for slaughter or breeding. The conventional animal-products often marketed include meat, milk, hides and skins, bones, horns, as well as blood. However, it is important to note that, due to the relatively crude methods of handling and slaughtering, only the income from meat constitutes any significant income to the farmers.

In Uganda, most of the meat is consumed fresh. Slaughtering may usually take place in abattoirs or on the farm. From there, the meat may be sold directly to the consumer or may be sold to the butcher, who will finally sell it to the consumer. Many livestock farmers are unable to produce and process products from their animals. This is due to a number of constraints, such as the lack of transport to and from the market, as well as lack of technology in terms of equipment as well as infrastructure; electricity and water.

Types of Livestock Markets

There are three types of livestock markets in Uganda, and these include:

- Primary (village) Markets: these are usually located in surplus producing areas and operate once or twice a month. They are mainly the points of assembly to supply secondary markets. However, farmers at the primary markets are facing infrastructure problems, such as poor forms of transport. The movement of livestock to the livestock-market is usually on foot. This causes stress and consequent loss in quality. The prices at this market are also settled by private treaty, leading to low prices in cases of distress sales during drought.

- Secondary Livestock Markets: these exist in or around large urban centres, such as district head-quarters. If the livestock are going to a secondary market within the district, they are normally transported on foot. The trader will usually hire a special herder to do this. The herd will be transported on lorries, only if there is demand from bigger cities. These large markets act as outlets for all types of sellers.

- Tertiary livestock markets: these livestock-markets are represented by the slaughterhouses and abattoirs, in the main urban city-centres, and slaughter-slums in sub counties within cities. There are also small functioning abattoirs at the district headquarters.

  There are two main abattoirs in Uganda, both of them situated in the capital city.

  In the traditional way of meat-processing and trade, there are a number of shortcomings e.g.:

  - The meat, as sold, contains a lot of inedible tissue, such as tendons and bones, which creates a disposal-problem for the final consumer, who is normally located in the urban areas.
  - The value of the meat produced is relatively low, since no prior processing is carried out.

PROCESSING

Meat, in general, has been part of the diet for most populations around the world ever since man began to hunt and fish. However, meat is a perishable good that will have to be treated in different ways, in order to keep well. The history of meat-processing started when man began to dry, smoke and cure meat. Since the early days, meat-processing has developed into almost an artistic skill, with a specific background. Products and techniques have been developed in order to satisfy customers and meet economic demands. Many of these processes can be adapted to rural situations.

Simple Meat-Processing Methods

Collection of meat: The quality of meat should be taken into consideration when selecting. The quality should be good, with less bone. For small-scale processing, there is recommendation for meat from the hind legs, as it has more meat than bone.

Deboning of meat: The meat is separated from the bones and other tissues. The meat for processing is cut into small pieces, which can pass through the mincer with ease.

Mincing: the mixture is then passed through the mincer for grinding into small pieces. In rural areas, where there is no power, a manual mincer is used. The only limitation here is that the quantity produced is small and there is demand for a lot of human labor.

Once the minced meat has been produced, a number of processed meat-products can be made. Processed meat-products are those which are made first by deboning, then the meat may be mixed with other non-meat materials, especially at village level. Materials, such as cassava, sweet potatoes, green pepper, onions, salt, curry powder, may all be mixed with the meat before it is ground. Then the meat mixture can be shaped differently to form a number of products, such as sausages, meatballs, burgers, samosas, beef chaps. These can then be fried or roasted and sold fresh.

Therefore, there are meat products, which are simple to make and do not constitute a quantum-leap in the equipment and processes that can be made in rural areas.

How Meat-Processing can Improve a Rural Community

Processing creates employment-opportunities for people at the village-level, e.g. a group of widows can form a group that will grow cassava and onions, to be used as part of the ingredients.

This increases profit, as most of the products have a longer shelf-life in comparison to the raw material. Quality products are made, as there is less bone in the product.

Nutritive value is increased when a number of other ingredients are added to the mixture of the meat.

The potential in meat/beef-processing is largely unexploited at the village-level. Opportunity therefore does exist in further processing of animal flesh into a variety of products.

CASSAVA PROCESSING AT VILLAGE-LEVEL

Because of Uganda's geographical position, it has good tropical soils and good climate. Uganda also has a lot of agricultural raw material (e.g. cassava, fruits, etc), most of which is organically produced. For this reason, Uganda has a good potential to process good-quality products to market, both domestically and regionally.

85% of the Ugandan population lives in rural areas and depend on agriculture for their livelihood (MAAIF, 1999). Food processing (value addition), thus, is needed to greatly improve livelihood of the farmer.

Cassava

Cassava is a major food crop in the region. In Uganda, cassava is the second most important root-crop, which rates second to banana as a food crop. The crop is grown throughout Uganda. The crop has an outstanding ability to withstand drought and remain in the soil after maturity, without any serious deterioration. Apart from being a stable food, it can be used for starch production. The world cassava-production is mainly for production of food, with the following distributions: 58% is eaten by humans, 28% fed to animals, 3% is processed into industrial products and 11% is wasted. In Uganda, most of the cassava is produced for human consumption. Eaten alone, cassava does not provide a lot of nutrients and is therefore considered a low-value food.

Varieties

In Uganda, there are two varieties of cassavas: the bitter variety, due to the high levels of gluco-cyanides, and the sweet varieties, which have lower levels of the gluco-cyanides. The bitter varieties contain a large amount of cyanides, these substances can cause various health problems and therefore the cassava must be processed before consumption. There are three efficient techniques, mainly used for processing bitter-cassava varieties, such as:

- Traditional dry fermentation
- Traditional wet fermentation
- Rapid fermentation (Gari).

Major Production Areas

Cassava-production areas are usually in the east (Soroti and Kumi) and north (Lira, Gulu). Others, parts of Masindi, Arua and regions in the West, also grow cassava. The cassava-growing areas overlap with livestock-raising areas, thus, making cassava a good vegetable candidate, as an additive for value-added meat products.

Agronomic Practices

There are two planting seasons, which coincide with the onset of the rains; these seasons are: March to June, and August to October.

Cassava requires between 6 months to 3 years: depending on variety and meteorological conditions.

Roots are usually harvested manually, by the farmer, and transported or carried on the head, care being taken during harvesting to avoid damage to the roots.

After harvesting, the family consumes the produce, either as:

- boiled cassava
- dried cassava
- mashed cassava

Causes of Post-Harvest Losses

- Lack of transport
- Rapid fresh-root perishability
- Over production
- Poor storage facilities
- Pest and diseases
- Damage during harvesting
- Poor marketability of produce

Transport, Storage and Marketing

Transport: Poor state of roads into local and regional markets is the main problem. 25% of the feeder roads are impassable during the rainy season, 45% still require rehabilitation and 20% need culverts and drainage repairs.

Storage: The storage facilities in Uganda at all levels i.e., farm, village and regional, are poor and inadequate. Mbarara, one of the major cassava-supply areas in the country experiences a shortage of 15,000 Tons during the off peak season. This is compounded by the lack of processing-facilities near the areas of production. An improved granary can be used, in order to achieve better storage results, such as a guard against pests.

However, mere storage is not the solution because very few crops maintain their quality during storage. The solution lies in long-term storage of crops in a processed form e.g. cassava flour, cassava starch, or dried cassava chips. However, value could be added by processing the cassava into other more nutritious products.

Marketing: There are two main reasons why produce does not usually find market; these include poor quality of the products and over production. Significant production depresses the market, so that loss in value can sometimes be as much as 90%.

Strategies to Reduce Post-Harvest Losses

- Avail of better transport system
- Leave the crop to stand in the garden and only harvest it when needed. The problem with this method is that the roots become fibrous and the quality is adversely affected. Land remains occupied for a long time, so that it cannot be put to other uses, which is uneconomic for the peasant farmer

- Burying the harvested cassava in wet grounds, after covering with saw-dust; this can only be a short-term measure.
- Processing of cassava is the best strategy

PROCESSING AT VILLAGE-LEVEL

Processing increases the availability of quality food, along with opportunities for the producers to generate more income, since processing by its very nature is value- addition.

1. Current Situation

Presently, Uganda processes only one percent of its agricultural produce and the value of cassava processed is much lower. This indicates that there is a vast potential for agro-based industries.

In order to penetrate new markets, and sustain old ones, it is necessary to develop quality-products that appeal and satisfy the buyers' needs. This can be done by simple appropriate technology equipment. At present,

- Not much value-addition is done to cassava i.e. it is not processed and is consumed virtually in its primary condition
- Perishable farm produce are wasted or sold at give away price due to inadequate post-harvest facilities and lack of effective processing or preservation techniques.

Processing includes primary processing (peeling) and secondary processing (product development and value addition).

2. Peeling and Fermentation

The tubers are peeled almost immediately. This removes half of the gluco-cyanide.

Fermentation has played a role for many years. It is the process used for marketed products, such as "gari" and "fufu". Usually, cassava may be fermented by immersing it in water. This process plays an important role in nutrient enrichment, because the non-protein nitrogen may be converted into protein.

3. Drying

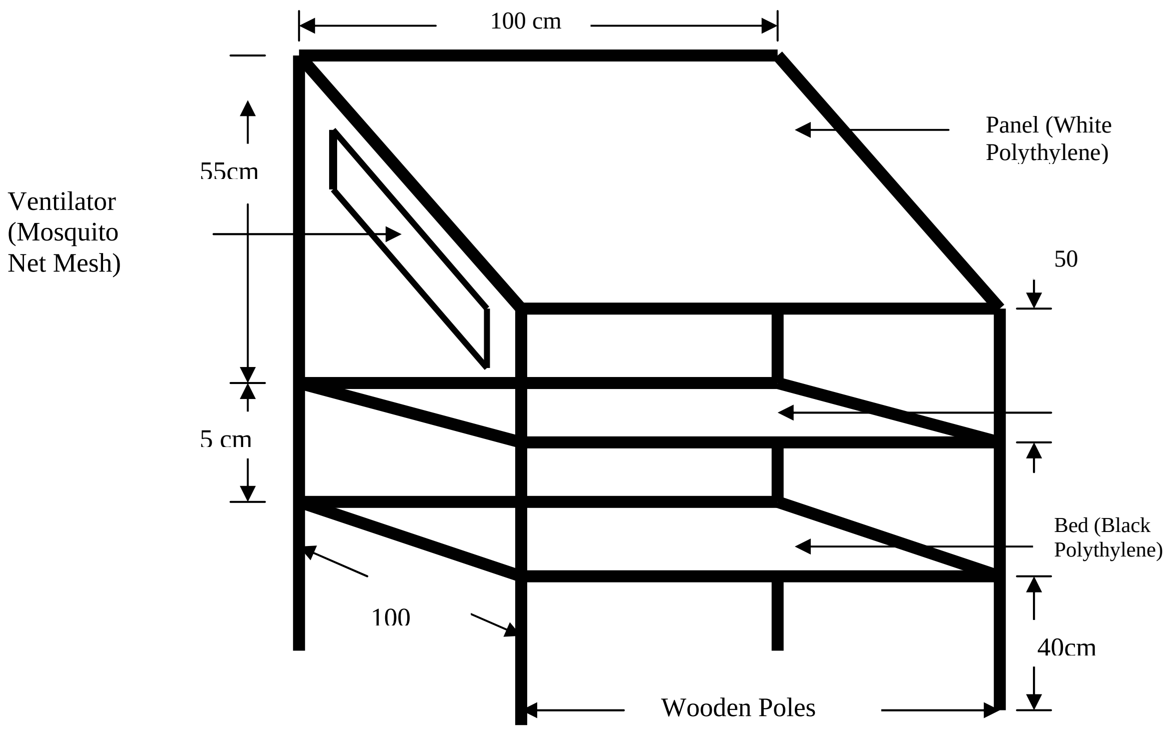
Cassava roots contain 61% of water, coupled with cyanide. During the drying process, there will be breakdown of cyanide. Drying can be carried out by traditional means, such as direct sun-dying or improved means, such as use of a solar dryer.

a. *Traditional drying:* Peeled cassava is put on the ground to dry under the sun; this leads to inclusion of many non-palatable materials like stones. A product dried in this way is not suitable for further processing, due to variation in quality.

b. *Improved methods e.g. using a solar dryer:* An improvement in drying can be attained by using a simple solar dryer shown below. A cabinet is used for drying the cassava. The drier is simple in design and does not require electricity. It can be fabricated from very simple materials, such as wood and polyethelene sheeting.

c. *Functions of Parts of the Solar Dries*

Panel: Constructed using polythylene (white). Must be inclined at a small angle and should face the east for better results.



Note: *All the vertical surfaces are constructed using white polythene*

Figure - 1: Diagram of Solar Dryer (in cm not to scale)

Ventilator:	Constructed, using the mosquito net mesh. It allows moisture to escape.
Drying Chamber:	Consists of a tray constructed of the mosquito-net mesh. Note that the tray is portable, hence the material can be easily put into or removed from the chamber.
Bed:	Constructed using polythene (black). It absorbs radiant energy from the sun and radiates the energy to effect the drying.
Wooden Poles:	Provides the framework.

Table - 2: Benefits of Using Improved Drying-Techniques, as Compared to the Traditional Drying Method

Traditional Drying Method	Improved Drying, Using the Solar Dryer
Cassava may got mouldy, thus affecting its quality	Quality of the product does not deteriorate, lose colour or texture
Loss through birds and animals	Loss does not usually occur, because the cassava is protected
Nutritive loss is higher e.g. Vitamin C	Nutritive loss is reduced
No uniform drying	Uniform
Cumbersome and time consuming	Less time consuming, less cumbersome
High possibility of foreign matter contamination	Reduced contamination

4. Milling or Grinding

Dried cassava is ground to make cassava flour. A number of products can then be made from this flour, such as:

- Pasta
- Cassava-flour rock buns

- Sponge cake
- Short-bread biscuits
- Cassava bread
- Meat balls
- Meat chaps
- Samosas

However, there are constraints such as:

- Processing is expensive in terms of both labour and running costs, as even the equipment recommended in this paper would require some form of investment from the farmer.

So, farmers should form unions associations so as to pool their resources to:

- Provide better transport and
- Buy better farming equipment;
- Eventually, build their own processing facilities.

In this way, they will improve their economic status because of better farming and value added to their products.

CONCLUSIONS

Major Advantages of Processing Technologies

- Minimise post-harvest losses
- Extend the shelf-life of food-produce, thus increasing food security
- Stabilise prices of raw materials during peak season
- Good returns to farmers
- Provide employment-opportunities
- Promote economic growth of the community
- Provides food of uniform quality, on a large scale
- To meet the food requirements, particularly in inaccessible areas
- To create new products of increased appeal and added value
- To provide nutritive value
- To promote the establishment and expansion of appropriate industries.

Food processing is quite restricted in most developing countries due to lack of knowledge and skills in modern and affordable processing methods. Other hindering factors are the difficulty to access funds, selection of suitable equipment and tools and technical support services. In most cases, the rural population has access to plenty of carbohydrates but is lacking animal protein in the diet.

Meat in many areas is considered a very expensive commodity in rural areas, not only in Uganda but in many developing countries, and annual per-capita consumption is below 4 kg. By mixing meat with other non-meat ingredients such as cassava, sweet potatoes, onions and other high-value but all the same lower costs, processed products can be obtained.

The products targeted are mainly fresh processed meat products, which can be processed at village-level, using simple equipment, most of it manually operated. This makes the production largely independent from expensive electrical power, thus cutting down on costs.

The processed products should be affordable by rural population. This can be achieved by incorporating non-meat ingredients, available in the locality, like cassava. This would contribute to marketability of local agricultural produce.

The generation of natural packing material, such as casings (for sausages) from intestines of slaughtered animals and the use of common spices, which can actually be grown in home gardens, avoids such expensive importation, thus cutting down on costs.

The Most Common Ingredients for such a Product are:

- Type of meat (beef, goats, sheep, pork, chicken, fish)
- Cassava (fresh and peeled or as flour or rush)
- Sweet potatoes (fresh and peeled or as starch)
- Onions (fresh and peeled or cooked)
- Green pepper
- Curry powder
- Common salt

The Process of Manufacturing Involves:

Deboning of meat

↓

Weighing of all ingredients

↓

Mixing of all ingredients

↓

Mincing the mixture

↓

Mixing the minced ingredients

↓

Shape mixture into meat balls, burgers, chaps,
or stuff mixture into casings to for sausages

Potential therefore exists in the processing of cassava at grass-roots into value-added products by addition to high-value products like meat and fish. However, the following issues must be addressed. These include:

- Improved post-harvest handling techniques e.g. solar drying
- Improved storage facilities
- Better transport
- Making good-quality products that appeal to consumers
- Farmers could form strong farmer-associations, which will assist the farmers to keep the business at the " roots"
- By products of the cassava, processing can be used as organic manure.

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SUSTAINABLE HUMAN RESOURCE DEVELOPMENT

*Abdullah Sadiq**

INTRODUCTION

The basic philosophy of Human Resource Development (HRD) underlies the fact that everything we do, including all of the tasks which led to this document, can be done better if we learn from our own relevant experiences as well as from the corresponding experiences of others. This underlies the human instinct to transfer knowledge and skills to offspring through grooming. Thus in every society parents consider it as their prime responsibility to develop their offspring into responsible, useful, and respectable members of their respective societies. Such transfer of knowledge and skills from parent to offspring or from the more experienced members of the society to the young generation predominantly takes place informally and is practiced even by certain species of mammals.

In extended families, in which arts and crafts are practiced as a profession, it is considered the joint responsibility of the whole family to bring up their youth as inheritors of their family traditions. With the development of handicrafts, cottage industry, and during the earlier phases of industrial revolution, the concept of guild and school was evolved for the more efficient and systematic transfer of knowledge and skills. This gave rise to the concept of masters and teachers as nation-builders. Human Resource Development, or HRD, refers to a more formal and systematic way of accomplishing this task. For this purpose one needs to document all significant experiences and package them for use in education and training. Such a reservoir of both individual and collective human knowledge, skills and experience forms the basis of HRD.

HUMAN RESOURCE DEVELOPMENT (HRD)

The development of human resource is the key to the development of all other resources. Traditionally labor, land and capital have been considered as the major resources, which are needed for the development of the society. Traditionally capital has usually played a more pivotal role among these three factors as it can be used to purchase the other two resources along with the necessary machinery and technology. The ever-increasing volume of more accessible, effective and powerful scientific and technical knowledge is gradually supplanting capital as the major resource for development.

In today’s knowledge-intensive economy inputs in the form of knowledge and skills have major impact on the quality of goods and services and result in drastic reduction in per unit costs. A vivid example of this trend is the fact that some 20 years ago a PC with 64k byte RAM, a megahertz speed and monochrome monitor used to cost equivalent of about 250,000 rupees. Today a thousands time more powerful branded PC with a megabytes RAM, over a thousand-megahertz speed, HVGA monitor, CD ROM drive and other multi-media features and superior in many other ways, can be purchased in less than one third of this amount.

In addition to the preceding purely economic factors, the development of human resource is necessary for much more important, albeit less tangible, reasons. High quality human resource reduces inequalities by promoting social mobility. This in turn encourages democratic values through autonomy and self-reliance. Besides, a critical number of educated citizens are a pre-requisite for the emergence of strong political and social institutions facilitating informed, enlightened and efficient decision-making, which is necessary for fairness and justice.

HRD FOR INDIVIDUALS AND ORGANIZATIONS

HRD refers to the career planning of individual members of society as well as the study of the developmental processes of organizations.

Individual career planning involves focussed and targeted education, training and skill development through on the job learning. This is done through an integrated systematic strategy to identify, assure, and help develop the key competencies that enable individuals to perform current or future jobs. It also

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involves the inculcation of healthy job and social ethics- dedication to and pride in one's profession, a healthy blend of competition and cooperation and concern for the welfare of the society. Thus HRD aspires to facilitate the ideal of socially useful self-fulfilling employment with adequate monetary and psychological rewards to all concerned.

Formal education and training is only the first step in a comprehensive strategy for HRD. A more systematic HRD program should eventually lead to the internalisation of knowledge, the refinement of skills and the development of healthy work and social ethics. This can only come through a long process of grooming where individuals are exposed to an active environment, which provides them ample opportunities to apply their knowledge and skills for the realization of well-defined challenging and socially relevant goals. In Pakistan, such an opportunity arose in the wake of the Indian nuclear tests of 1974 and the subsequent embargoes on the transfer of strategic technologies. This led to intense, albeit limited, R&D activities in the diverse disciplines of engineering, science and technology and the consequent grooming of engineers, scientists and technicians associated with these activities.

The other facet of HRD is the integrated area of study of the development practices of organizations so that they may accomplish higher level of individual and organizational effectiveness. In this case, it uses organization development as a focus for assuring healthy inter-and intra-unit relationships. This helps initiate and manage change by facilitating individuals and groups to effectively impact on the organization as a system.

HRD also focuses on career development, assuring an alignment of individual career planning and organizational career management processes to achieve an optimum match of individual and organizational needs.

An appropriate investment in HRD can help in the development of a healthy and strong society by enabling a majority of its individual members to contribute positively through their labour, their social actions and their financial activities towards its well-being. HRD, through its various program areas and in conjunction with the rest of the educational, industrial, government and business systems, is charged with the preparation and development of young people and adults towards this end.

CRITICAL FACTORS FOR SUSTAINABLE HRD

Some of the critical factors for sustainable HRD are:

1. Population explosion,
2. The rising expectations, and
3. The ongoing knowledge revolution.

Because of the first two factors educational and training facilities have to cater to an ever-increasing number of people every year. This results in the very thin spreading of the already meagre education and training resources of the countries of South, further deteriorating the quality of education services. Some of these problems can be overcome through the following steps;

i. Giving more autonomy to institutions,
ii. More flexible and responsive management practices which can make more efficient use of existing resources,
iii. Public-private partnership and resource sharing among institutions, and
iv. Stratification, allowing institutions to play their strengths and serve different needs.

The ongoing knowledge revolution provides both challenges and opportunities to the planner of HRD programs. The challenges stem from the fact that participation in the knowledge-based economy requires a new set of human skills. People need to have higher qualifications and to be capable of greater intellectual independence. They must be flexible and be able to continue learning much beyond the traditional age for schooling. Without improving their human capital, countries of the South will inevitably fall behind and experience intellectual and economic marginalization and isolation. The result will be continuing, if not rising, poverty, social unrest and even more human misery than witnessed today.

The knowledge revolution also calls for additional funds for:

1. Regular reviews of the contents of education and training to keep it relevant and up to date,
2. Updating and supplementing library and laboratory resources, and
3. Increasing emphasis on higher education.

There is, thus, a need to strike a balance between general and specialized education. The former encourages flexibility and innovation, thus allowing the continued renewal of economic and social structures relevant to the fast changing world. The latter emphasizes teaching students not only what is currently known, but also to keep knowledge up to date, so that they will be able to refresh their skills as the economic environment changes.

The opportunities are provided by the spin-off technologies of the knowledge revolution, the enabling technologies of IT and the Internet. These technologies provide convenient access to the reservoir of the human knowledge and skills cumulated over the centuries. They also make it possible to provide education and training to a much larger number of people at significantly lower costs through the distant learning and virtual university schemes. In this way the knowledge revolution, while putting additional demands on the limited financial resources, can also redress some of the problems, which arise from the changing demography and the rising expectations it fuels.

SOME EXAMPLES OF NON-SUSTAINABLE HRD

Certain aspects of the existing HRD scheme pertaining to secondary and tertiary education are not sustainable. These are;

i. The ever increasing number of students opting for O-level and A-level examinations and other externally conducted examinations required for admissions abroad,
ii. The requirement of certain private-sector universities to have the grades of SAT and GRE tests as criterion for admission,
iii. The increasing number of young people going abroad for higher studies, and
iv. The consequent brain drain of educated and skilled manpower from the country.

The first two of these, desirable as they are, are not sustainable for purely financial reasons. It is estimated that around 50 million dollars is remitted outside the country for O- and A-level examinations alone. A similar amount may be spent on the foreign admission related examinations such as SAT, GRE, GMAT, TOEFL, etc; and their related admission formalities.

Requiring students to take SAT, GRE and other such standard reliable examinations is also highly desirable. However, in addition to further straining the meagre foreign exchange resources of the country such practice is highly discriminatory in nature against the poorer section of the population. It also further erodes the credibility of local institutions and stunts their development.

A possible way out of this dilemma is to develop and strengthen credible institutions, with foreign help and assistance if needed, both for testing and for HRD in certain key areas. The foreign tests can be used for initial calibration and for establishing the credibility of local testing services.

INTERMEDIATE TECHNOLOGY - AN APPROPRIATE DEVELOPMENTAL PATH

*Q. Isa Daudpota**

ABSTRACT

A major part of this paper reviews the reasons for the failure of conventional science and technology policies in developing countries. Such policies have overlooked the concerns of the majority of the rural poor. Change is now necessitated by national and global environmental concerns, and by the need to recognize that the welfare of the poor is in the self-interest of all governments.

> *"…the major obstacle to the development of the rural poor is the so-called educated man."*
> *-- Bunker Roy, Indian Express, 1983.*

Alternative or Intermediate Technology is subversive. It questions the current direction of technological development, and forces us to look at our own motivation for working on science and technology issues. It makes us feel awkward, just as Roy's quotation does. As social, economic and political problems increase in our technology-driven world, it is important to inquire where we may have gone wrong, and to seek alternative paths to sustainable development. Could it be that in our mad rush to follow the current norms of development, we have missed out important features of the process of acquiring knowledge, and its subsequent use?

It is in the richer countries, which invested in science and technology (S&T) that most of the technological changes associated with industrial development have taken place. Only one-third of the global population that resides in the developed countries is directly affected by these changes. The remaining two-third, the majority of people, lives in the Third World.

The high living standards in the North, a result of industrialization (and colonization), suggested to the poorer countries that they too could solve their problems by using S&T. The nature of the relationship between S&T and society in the Third World is, however, quite different from that in the North. Much of it is due to the difference in the distribution of populations in their respective urban and rural areas. In the Third World, 70-80 percent of the people are involved in agriculture in the villages, while only 5 percent or less live in the rural areas of the industrialized countries. Such a big difference highlights the need to think carefully about the role of western S&T in the development of the Third World.

WHAT IS DEVELOPMENT?

The concept of 'development' is complex and does not allow for an easy definition. Some may equate development with economic growth, or simply becoming more like the industrialized countries, but others reject such a simple description. This is because economic growth does not necessarily reach the most needy; especially where there is gross inequality in wealth-distribution in the country. Invariably, only the richest 10-20 percent in the developing countries benefit. With Industrialization come problems that the affluent world seems unable to cope with, such as environmental degradation, high degree of urbanization and insatiable consumerism. Far better than, say many observers in the Third World, to avoid the old pattern of 'development' that has been shown to lead to such problems. It seems prudent to emphasize sustainability in production and consumption, combined with desirable characteristics of pre-industrial society, such as decentralization, social integration, resource conservation and so on.

The developing world in the post-colonial era has followed the pattern of the industrialized countries before them. Despite the Gandhian idea of an independence movement that led to economic progress through self-reliance, with an emphasis on small-scale village-level activities, Nehru's socialist leaning copied the Soviet model of industrialization. This led to the setting up of a range of heavy industries in the public-sector, to manufacture goods that were previously imported from Britain and other countries. In addition, the government funded the setting up of a number of institutes of technology and higher learning, to help produce high-quality scientists and technologists.

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Such large-scale undertakings led to optimism that industrialization in these newly developing countries would be rapid and be achieved in far less time than the early industrial countries, such as Britain and Germany. It was believed that the developing countries would be able to acquire the know-how and the resources needed as part of a generous transfer of technology. It was expected that this would come as aid, or through the returning bright students who were sent to the former colonizers to acquire skills and degrees.

This sense of optimism had also infected the United Nations, and it set up an advisory committee to prepare a global plan of action for using S&T for development. But this enthusiasm began to vane by the end of the 1970s. A more skeptical view of the role of S&T arose, as a matter of fact, from the result of the work carried out by the UN and its agencies. This happened as the UN searched for policy measures to help enhance the influence of S&T on development.

RE-THINKING THE WESTERN MODEL

The re-appraisal of the role of Western S&T in developing countries was helped by the UN's Advisory Committee Report (ACAST 1970) [1]. It pointed out that the Third World's meager expenditure on R&D was often uncoordinated and poorly directed, and that the projects undertaken had little or no relation to the needs of the poor countries. Priority was given to areas of 'basic' research, to the exclusion of 'applied' research that had ready applicability to everyday problems, in critical areas such as health, energy, agriculture, transport and housing. Much of the S&T research took its cue from problems that the foreign-trained researchers had picked up from their supervisors in the laboratories of Europe. This elitist activity, which on occasions produced accolades from overseas, was adopted to the exclusion of other equally 'exciting' and socially relevant projects. Here, incentives for R&D workers to produce solutions to such problems would have helped. What was also needed were linkages and infrastructure for product development. The failure to put these in place made research a 'marginal' or 'enclave' activity.

The structure of the post-colonial economies was such that it did not create any significant demand on the local R&D workers to innovate. Most of the country's need for food and natural resources came from agriculture and mining, both of which were not especially research intensive. Utilizing formal agricultural studies and applying this knowledge in practice did not exist; much of what was needed came from traditional local knowledge. Neither the government nor the private sector, which comprised big companies headquartered in Europe, were interested in or had confidence in locally manufactured goods. A complete factory, such as a sugar mill or a fertilizer factory, could be imported and it merely required local labor and management to get it up and running. Turnkey projects were the norm – this suited the government official, who then needn't risk opting for an untried product. It also suited the foreign company, which gained by getting a well-tried product that had worked successfully in the home country, and also in others to which it had been exported.

As a result of all these factors, only weak links were established between S&T and production in the Third World. [*Contrast this with how R&D and industry developed in the industrial countries*]. The turnkey industries needed little more than maintenance technicians. Hence, the highly trained professionals, unable to find work, left to take up jobs in the developed countries. Having been trained in their technologies, they were welcomed -- a reverse form of foreign aid from the poor countries to the rich!

The impact of Western technology imports was to have an even more profound impact on the peasant farmer and the poor urban worker who, without the opportunity of finding overseas employment, found himself unemployed or under-employed. A number of research studies in the 1970s showed how imported technologies generated only a few local jobs and often destroyed thousands that existed. Adding insult to injury, it became apparent that the Third World could not gain from the machinery and processes that had already been developed in the West. Patented technology transferred from a parent company in the developed country to a subsidiary in the Third World was overcharged, often by a factor of ten.

WESTERN TECHNOLOGY'S IMPACT ON RURAL MASSES

In the rural sector, the introduction in the 1960s of Western technology for increasing yield of rice and wheat had a debilitating impact on the poor farmers. This Green Revolution promised increased yields, but under very demanding conditions and expensive inputs, such as application of regular large doses of fertilizers and water. It disregarded the needs of rain-fed agriculture, which is critical for the survival of a vast number of poor farmers. Through this ‘revolution’, the rich farmer became richer, buying out the tenant farmer, whose next refuge became the nearby city where he could seek a job as a laborer.

The need for mechanical harvesting that accompanied the high-yield technology greatly reduced the need for the traditional harvesters of rice: women. Moreover, little attention was paid to the small-scale backyard production of food, carried out by women in home gardens. Nor was there any attempt made to improving the technology used in homes, which would help women in their daily chores, e.g. cooking, cleaning, collecting firewood and water, which occupied so much time and effort (Chambers, 1983) [2]. Had the politicians and bureaucrats paid attention to the problems of the poor rural women, the agricultural output and overall health of the rural population would have improved.

The Third World’s massive and growing army of unemployed and under-employed people demands the creation of millions of new and more productive workplaces. In practice, this means making available to the rural people, on a large scale, better tools, equipment and facilities. But what are these technologies that will raise the incomes of the rural poor, on a sustainable basis? Who can produce these technologies? How can poor people get access to them, and own them? *These are the questions we should be asking today.*

SCHUMACHER AND INTERMEDIATE TECHNOLOGY

The person who helped analyze this dilemma of Third-World development was Fritz Schumacher. He advocated the idea of Intermediate Technology as an alternative - it was to fit the gap between the centuries-old technologies that the rural poor used and the advanced Western ones. Traditional technologies were not productive enough to get the people out of the poverty trap. At the same time, imported technology was far too expensive for most Third-World people and could not eliminate poverty. In turn, it would never generate the number of jobs necessary to keep the large numbers of the rural population gainfully employed. Schumacher outlined his theory in a series of essays; later compiled into a book (Schumacher 19730) [3], which started a movement that recognized the need for both the developing world and the West to think ‘small’ so as to ensure sustainability. The message was particularly relevant for the developing world, which until then had tried the high technology route and failed to provide jobs and well being for the vast majority of its population.

To help put his ideas into practice, Schumacher founded the Intermediate Technology Development Group (ITDG), which has undertaken many practical and appropriate projects in sectors such as health, rural development, energy, building-technology, water and sanitation, as well as others. An example of a success-story is the production of bricks for improved construction of homes in the developing countries. In the industrialized world, a large brick-factory produces a million bricks weekly and is very expensive to build and operate. The ITDG developed small-scale alternatives, which produced only 10,000 bricks weekly, using hand-operated methods, and simple machinery. Capital-cost per workplace (i.e. the money used to set up a workplace for a single worker) was UK Pounds 400, compared with hundred times higher cost---workplace for the high-volume factory. The bricks produced in smaller quantities were also only half the price of the others. Such plants were set up in several countries of Africa.

The Third World’s own experience with this kind of appropriate technology brought out an alternative system of energy and fertilizer production: biogas fermentation. Much of this work came out of experimental plants set up in India and China. Through a process of anaerobic microbial fermentation, a biogas plant is able to turn vegetable matter, animal manure and other waste materials into nitrogen-rich slurry, which can be used as a fertilizer. The methane gas produced, as a result of the process, is stored and can be used for cooking and even driving electric generators. A comparison of biogas fertilizer plant and the conventional Western fertilizer technology is given in the table below:

Table - 1: Production of fertilizer by Western and Alternative Technologies
(230,000 Tonnes of Nitrogen Per Year)

	Western Technology (large-scale coal-based fertilizer plant)	**Intermediate Technology** (village-scale bio-gas fertilizer plant)
Number of plants	1	26,150
Capital Cost	Rs 1.200 billion	Rs 1.070 billion
Foreign Exchange	Rs 600 million	Nil
Employment	1000	130,750
Energy	About 0.1 million MWH *consumed* per annum	About 6.35 million MWH *produced* per annum

Source: (Reddy 19750) [4]

Examples such as this encouraged many observers to use Intermediate Technology as the model to achieve self-reliance and generate jobs in a sustainable way. This was seen as an appropriate way of reducing the reliance on over-priced and divisive technology obtained from outside. But there were alternative viewpoints, which did not support this optimistic opinion. Was this not a way of keeping the developing world backward by making it get along with second-rate technology? Others felt that such a technology would not be widely accepted, as it was not well grounded in the then-prevailing social and political structures. The proponents of Intermediate Technology viewed it as a means of generating employment and creating a more just society, based on small-scale industry. Unfortunately, this ignored the existing gaping income inequality in the developing world, where the decision-makers who make science and technology policies demand luxury motor cars, expensive kitchen implements, fashionable clothes, lavish houses, etc. Given such a choice of products, the technology for obtaining them cannot be of a small scale and be built cheaply. The continuing inequality of distribution in wealth therefore seemingly condemns the developing countries to continue on their self-destructive path. But this is where political wisdom can ensure a “turn around”, as would an enlightened public globally, which sees the need for change.

CONCLUSIONS

Simplifying technologies to make them efficient and affordable for the rural population requires the finest minds and the most sophisticated equipment to develop it. To help this, our educational and R&D systems need to be designed to encourage a deep involvement of academics and researchers, instead of continuing to train and work on problems that currently interest mainly the advanced Western economies.

The environmental movements in the West are now creating increasing pressure on their governments to review their mode of production, and so develop ‘softer’ technologies based on renewable energy resources. There is also a realization that the increased consumption in thickly populated countries, such as India and China, would lead to massive environmental damage over and above that caused by Western consumption. The West therefore needs to collaborate with the developing countries, to set a new pattern of technology-development directed at solving the issues of real needs of the vast majority of people on this planet. It must begin with the concerns of the rural poor in the developing world, and hence with using technology appropriate for meeting their needs.

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SCIENCE AND TECHNOLOGY FOR INDUSTRIALIZATION

*S.T.K. Naim**

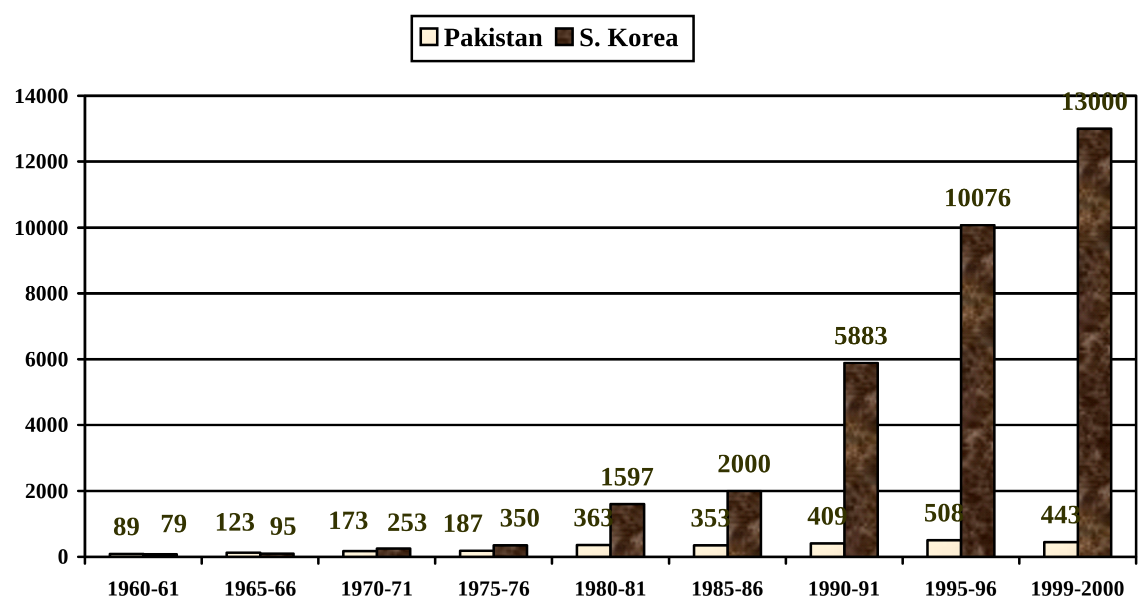
ABSTRACT

Technology considerations have been introduced in economic theory and there is no doubt in the minds of most policy makers that technological improvements are usually linked to economic growth and higher standards of living. Nowhere has this been more evident than in the economic miracles achieved by East Asian countries in the last three decades where high economic growth was accompanied by improved income distribution.

Developing indigenous S&T capabilities for industrialization is dependent on several factors which include historical and cultural traditions, political and economic stability, particularly attainment in science education, natural resources, the structure of firms, financial institutions, modes of technology transfer and market forces. An all-encompassing formula for countries to emulate does not exit, yet there are lessons to be learnt from the experiences of East Asian countries.

This article reviews the S&T policies followed by South Korea in the last five decades. The role of S&T policy in industrialization and its impact on the economy is discussed[1]. The comparison with Pakistan's S&T policy highlights its weakness as well as its non-integration with economic, industrial, educational and other policies related to the socio-economic development of the country.

South Korea has witnessed unprecedented economic growth in the last three decades. Figure-1 shows the comparison of the growth in per capita GNP for both Pakistan and South Korea during last four decades.



Source Pakistan: UNESCO, Statistical Year Book 1980, 1982, 1991 and Economic Survey of Pakistan
Source South Korea: Science & Technology Policy Institute (STEPI), South Korea

Figure - 1: Growth of Per Capita GNP (US$)

The GDP growth rate in Korea has been over 8 percent per annum. Being one of the poorest countries in the 1960s with per capita GNP of $ 79, Korea is fast catching up with the western industrialized economies with per capita GNP of $13,000 in the year 2000. Its economic growth has also accompanied better income distribution and improved quality of life for the majority of its people[2].

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By contrast, in Pakistan the ratio of people living below the poverty line has increased from 30 percent in 1971 to 47.8 percent in year 2000. In the last decade, the country has experienced continuous economic and social deterioration which is reflected in low average annual growth rate of GNP and a large segment of the population living in poverty[3].

HUMAN RESOURCE DEVELOPMENT

Several studies have shown that educational attainment has a positive impact on growth and contributes to reducing inequalities. Similarly many experts have argued that availability of a highly skilled labour force contributes towards productivity and enhancing the profitability of investment[4].

In 1964 Herbison and Myer[5], using data from developing countries, found South Korea, Taiwan and Yugoslavia with levels of educational achievements far above other countries. A knowledge base had been created earlier on. Government policies supporting broad based high quality education are frequently mentioned as common features behind economic growth of these economies. Certainly a broad knowledge base has become the cornerstone for building modern societies.

Table - 1: Shows the Comparison of Literacy Rate and Enrolments Between South Korea and Pakistan

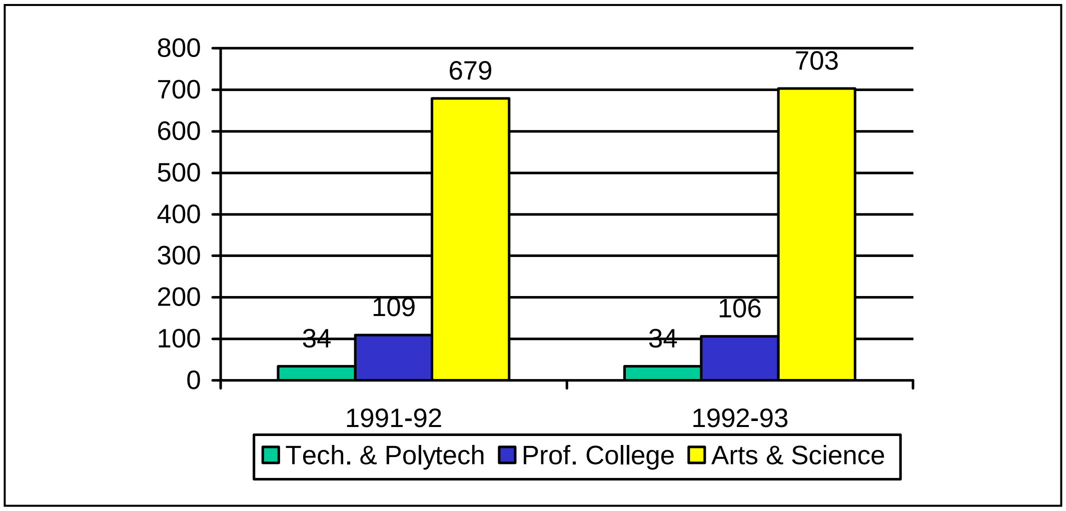
Age	Percentage of Enrolments by Age Group			
	1970	1980	1990	1995
Illiteracy Rate	10.6	0	0	0
Elementary School 6-11	100.7	102.9	100.9	98.7
Middle School 12-14	51.2	95.1	96.3	100.6
High School 15-17	28.1	63.5	86.8	89.9
Tertiary 18+	8.8	16.0	37.6	54.6

Age	Percentage of Enrolments by Age Group						
	1970	1975	1980	1985	1990	1995	2000
Illiteracy Rate	NA	NA	72.1	68.5	64.5	60.6	56.7
Elementary School (5-9)	36	40	40	44	61	71	89.0
Middle School (10-12)	13	15	14	17	23	45.8	47.5
High School (13-16)						30.8	29.5
Tertiary (17-23)	2	2	NA	2	3	3	2.6*

Source: i) UNESCO Statistical Year Book 1999
ii) S&T Indicators of Pak (1999-2000)

Pakistan's literacy rate is exceedingly low and despite increase in the number of universities and other educational institutions, the quality of education has not shown much improvement. Expenditure on education has also been low as no government showed the requisite commitment towards educating the masses. The quality of education at all levels suffers due to shortage of qualified teachers. High drop out rates at primary level not only reflect the social/economic problems but low quality and lack of efficiency exhibited by the Pakistan educational system.

In most developed countries the enrolment-ratio in general technical education is 50:50 if not more in favour of technical education. In Pakistan the ratio is 9:1 (Figure-2). This is mainly because of the disregard of technical education towards the job market.



Source: (i) Economic Survey 1997-98 (ii) Pakistan Statistical Year Book-1995
(iii)Federal Bureau of Statistics, Pakistan

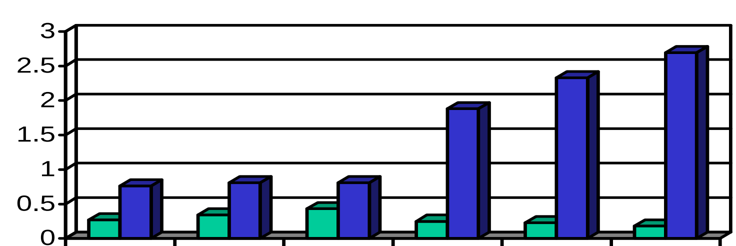
Figure - 2: Comparison of Enrolments

For example none of the technical colleges are providing training in production techniques. The other reasons for technical education not been able to attract a large number of students is the low prestige attached to the profession.

INVESTMENT IN RESEARCH AND DEVELOPMENT

Besides education and training of human resources, R&D activities are essential for building knowledge based economies. R&D conducted at academic institutions and industry are key to the accumulation of knowledge required to strengthen innovation. Expenditure on R&D is an important indicator which is equated to the economic development. More meaningful is R&D expenditure by the private sector or by industry.

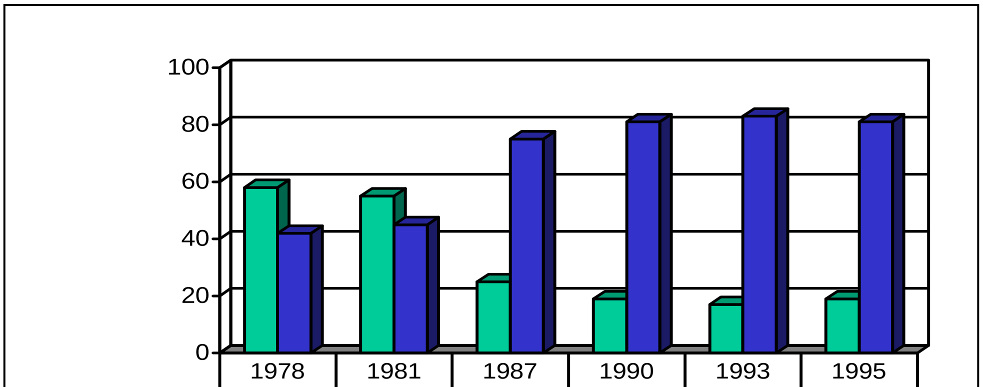
Figure 3-4 shows comparative investment in R&D for Pakistan and South Korea and also the growth of private investment in R&D in South Korea. The R&D expenditure of private firms increased from $3.36 billion in 1990 to $8 .95 billion in 1995 contributing almost 81 percent of total R&D expenditure. The number of private R&D organizations grew from one in 1970 to 2270 in 1995[6]. According to G. Cardoza, the investments in education and R&D not only have positive effect on knowledge accumulation (Scientific publications and industrial innovation patents etc.) but also seem to have a positive impact on employees' productivity.



	1978	1981	1987	1990	1993	1995
Pakistan	0.27	0.34	0.43	0.25	0.23	0.18
S. Korea	0.76	0.81	0.81	1.88	2.33	2.69

Source: i) PCST Publication, S&T Potential of R&D Organizations, 1990 ii) PCST Publication, S&T Indicators of Pakistan, 1999, iii) Science Policy Cell, MoST, December 1987, iv) MoST, Science and Technology Annals, (S. Korea) various years

Figure - 3: Comparison of R&D Expenditures as Percentage of GNP Pakistan & South Korea

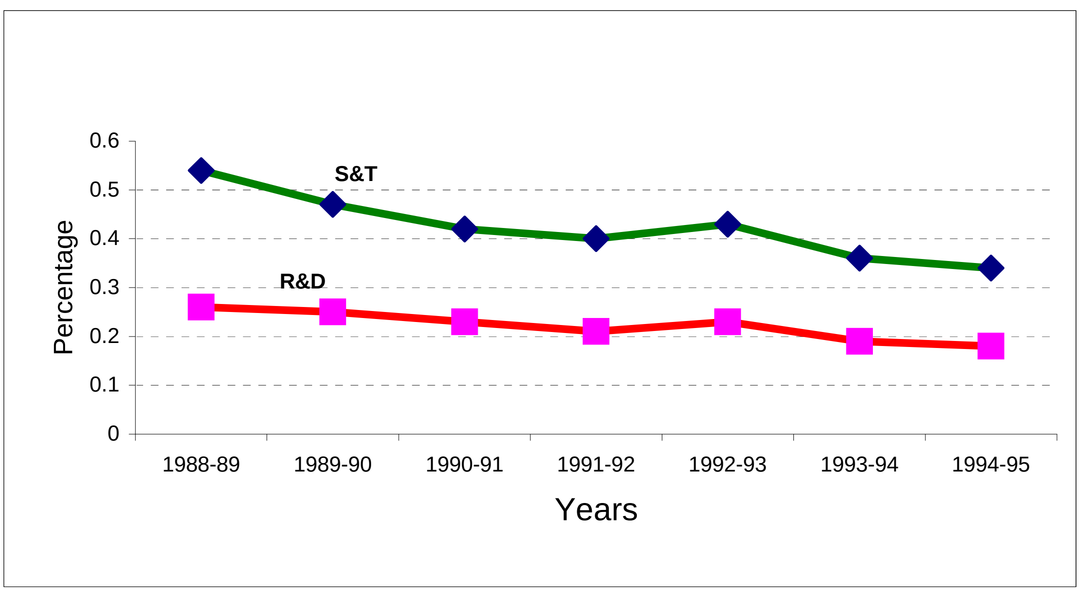


	1978	1981	1987	1990	1993	1995
Government	58	55	25	19	17	19
Private	42	45	75	81	83	81

Source: MoST, Science and Technology Annals (South Korea)

Figure - 4: Government Vs. Private R&D Expenditure (Billion won) **South Korea**

R&D expenditure in Pakistan stagnated for several years between 0.15 to 0.18 percent of GNP. (Figure-5) shows trends in R&D expenditure for the last 20 years. With considerable increase in the number of R&D organizations, the R&D budget mostly contributed by the public sector was distributed very thinly. The private sector contribution to R&D is not documented but there is enough evidence to assume that private sector is neither seeking help from public R&D organizations nor conducting in-house R&D activities[11].



Source: PCST Data, Pakistan Economic Survey 1996-97

Figure - 5: Public Sector (Non-Classified) S&T and R&D Budgets as Percent of GNP (1988-1995)

On the contrary, South Korean firms not only intensified in-house R&D from 1980 onwards, but also began globalizing their R&D activities and building strategic alliances.

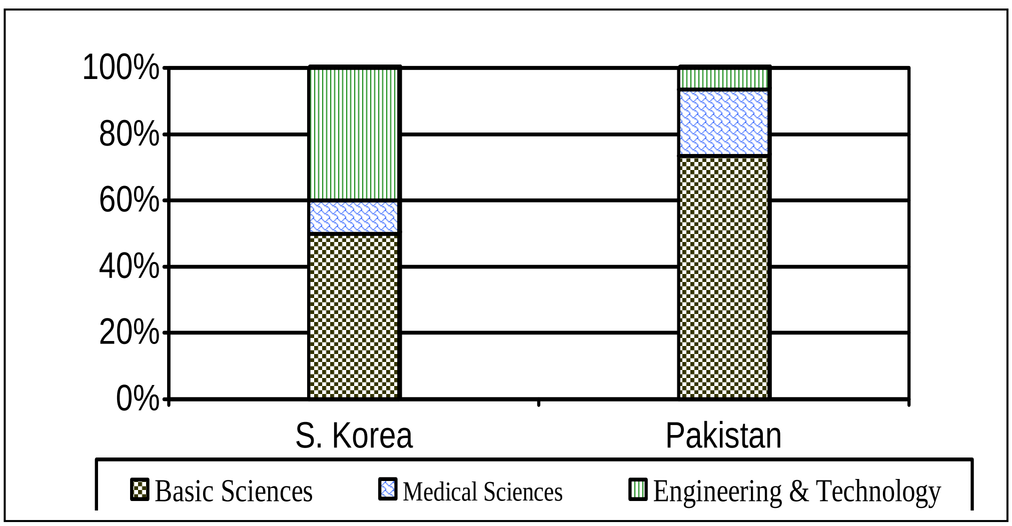
An example of reverse engineering and subsequent technological improvement in South Korea is the development of the microwave oven by SAMSUNG. In 1976, after Japanese and US firms refused to transfer technology, SAMSUNG organized a task force to collect information, evaluate technical possibilities and undertake reverse engineering in order to develop its own microwave oven. In addition, to gain access to the technology of the Magnetron tube used in microwave ovens, SAMSUNG acquired a US company facing financial difficulties. After two years of trial and error, SAMSUNG was not only able to reverse-engineer the microwave oven but also to become one of the world's largest exporters of this product.

To guarantee access to new knowledge and accelerate the rate of innovation, electronics firms adopted a mixed strategy which combined in-house R&D, strategic alliances, acquisition of high-tech firms, establishment of international R&D networks and development of their own engineering, design and organizational capabilities. The R&D networks included joint R&D projects with other local or foreign firms and R&D outposts in developed countries. These new collaborative arrangements represented an important step in the process of diversifying the sources of knowledge and expertise[8].

OUTPUT OF SCIENTIFIC RESEARCH

Research Publications

As can be seen from Figure-6 the greatest percentage of scientific papers published from Pakistan (1995) was in the field of basic and medical sciences. In South Korea (1993) there was a more balanced distribution of scientific publication between basic and applied sciences with a large proportion of publications in engineering and new technology fields (36%).



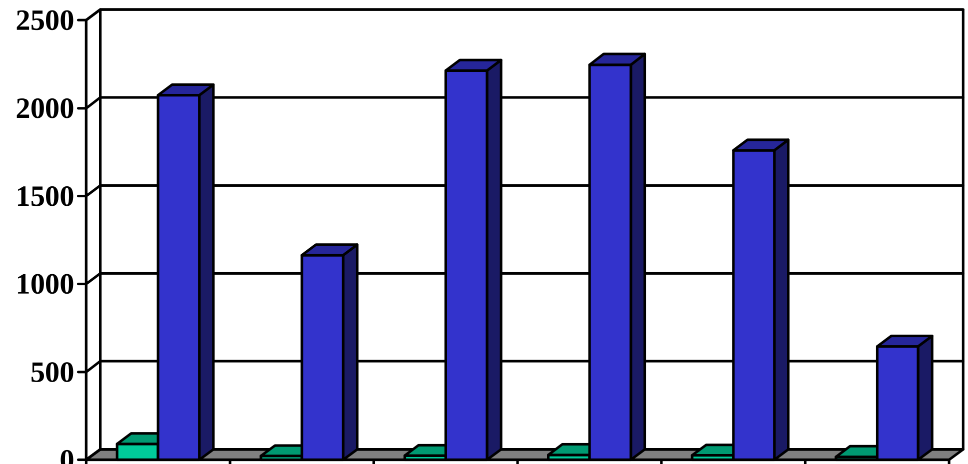
Source: S. Korea, Science and Public Policy Dec. 1997 Pakistan, PCST Report

Figure - 6: Distribution of Scientific Papers by Fields S. Korea and Pakistan

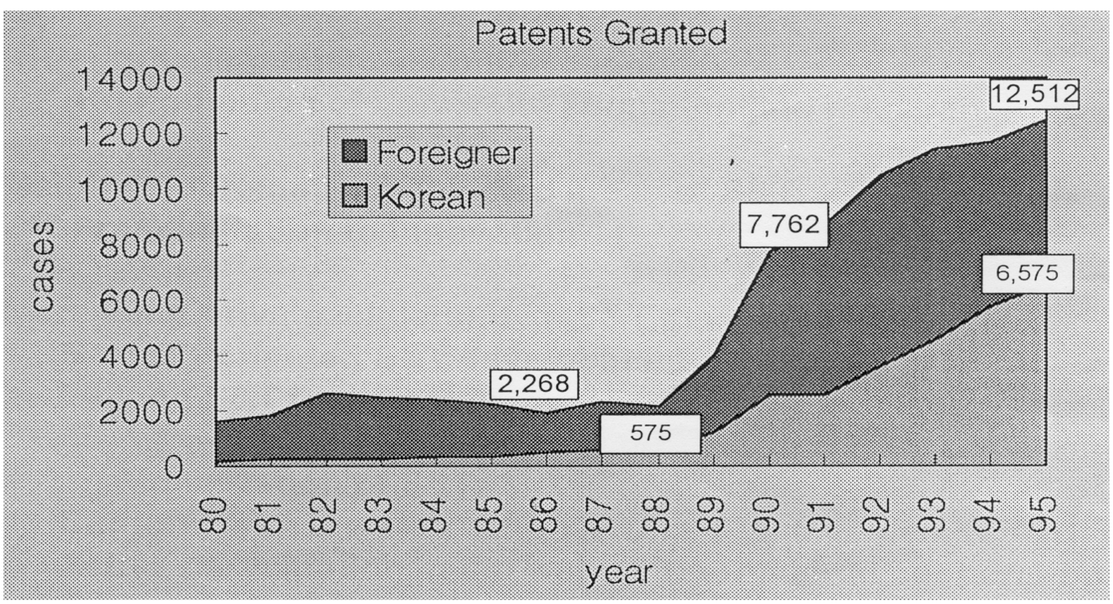
This indicates a strong orientation towards applied research in South Korea as well as close linkages established between academic research and industry.

Another important indicator of South Korea's rapid growth in industrial R&D is patent registration (Figure-7). Domestic Patent growth has significantly increased from 575 in 1987-88 to 6575 in 1994-95. In Pakistan the registration of patents from local origin shows a declining trend over the years. There were 90 patents (domestic) registered in 1976-1980 and only 17 in 1999-2000.

Pakistan



	1976-80	1981-85	1986-90	1991-95	1996-98	30-6-1999
Local Origin	90	22	24	28	25	17
Foreign Origin	2074	1164	2213	2247	1760	644



Source: Pakistan Patents & Design Office Karachi
Science & Technology Policy Institute (STEPI), Korea

Figure - 7: The Trend of Patents Granted

ROLE OF R&D ORGANIZATIONS

Establishment of KIST:

In 1966 the South Korean Institute for Science and Technology (KIST), a multidisciplinary research institute, was established with the help of Battelle Memorial Institute on three basic principles[6]:

i. Autonomous Management, Research Ambience and Financial Stability: KIST Assistance Act, was promulgated in 1966, ensured an Endowment Funding System. The Endowment Fund was guaranteed by the government and could be used for basic operations and capital expenditure for construction.
ii. Contract Research System: All R&D work commissioned to the Institute was in the form of contracts whether from government or the private sector.
iii. Responsibility Centre Structure: Individual labs were supposed to be the basic unit of the management of the Institute. These labs were to earn enough from contract research to pay for human resources and facilities.

As the South Korean economy diversified and KIST was unable to meet ever-increasing demand, the government established the Government Research Institutes (GRIs) for strategic industries: chemicals, machinery and metals, electronics, shipbuilding etc.

In the early stages of industrialization, the private sector was reluctant to commercialise the technologies developed by KIST as they were sceptical of its engineering and production capability. Also KIST could not complete against foreign firms in supplying detailed blue-prints and other manufacturing know-how as well as being unable to assist industries in solving teething problems in the initial stages of production. Therefore KIST founded the South Korea Technology Advancement Corporation (K-TAC) a non-profit venture to commercialise ifs research.

One of the important roles that KIST played at this stage was in helping industries strengthen their bargaining power in acquiring foreign technology. Once imported such joint ventures provided a platform on which the firms could assimilate and adapt technology rapidly – KIST played a significant role in transferring technology to industry through reverse engineering. An important example is the production of polyester film for use in cassette tapes. When a Japanese company rejected South Korean requests for fear of losing its market in South Korea, a South Korean firm, in collaboration with KIST, successfully undertook a reverse engineering task to invent around the production technology. South Korea is now the world's major supplier for audio and videocassette tapes.

DIVERSIFICATION OF EXPORTS

South Korea's transformation from an agrarian economy to an industrial knowledge-based economy was achieved through policies of constant learning and innovation. During the 1950s and 60s, South Korea was exporting low- cost labour-intensive manufactures such as plywood, wigs, toys and textiles. During the 70s as skilled South Korean workers mastered foreign technologies and gained experience, they began exporting ships, steel, consumer electronics and construction services. By the mid-80s S. Korea moved towards the next phase of industrialization characterized by skilled, labour-intensive industries, computers, semi-conductors, memory chips, videocassette recorders, electronic switching systems, automobiles, industrial plants and other technology and knowledge intensive products.

In the 90s the S. Korean workers began working on the next generation products such as multi-media electronics, high definition TVs, personal telecommunication systems (Figure-8).

An important factor contributing to the economic growth of S. Korea as cited by Young (1993) and Krugman (1994) was the rapid expansion of employment in manufacturing, mainly due to the adoption of an outward, export-oriented development strategy that allowed for rapid increase of labour demand and incorporation of new entrants into economy.

An export-led economic growth model and appropriate system of incentives provided the direction for industrialization. Export oriented growth strategies helped S. Korea achieve industrial specialization, which involved constant innovation in the improvement of products and processes and generated a sustained demand for highly skilled human resources. Indeed export driven strategies are argued to be among the most important factors explaining the success stories of S. Korea[10].

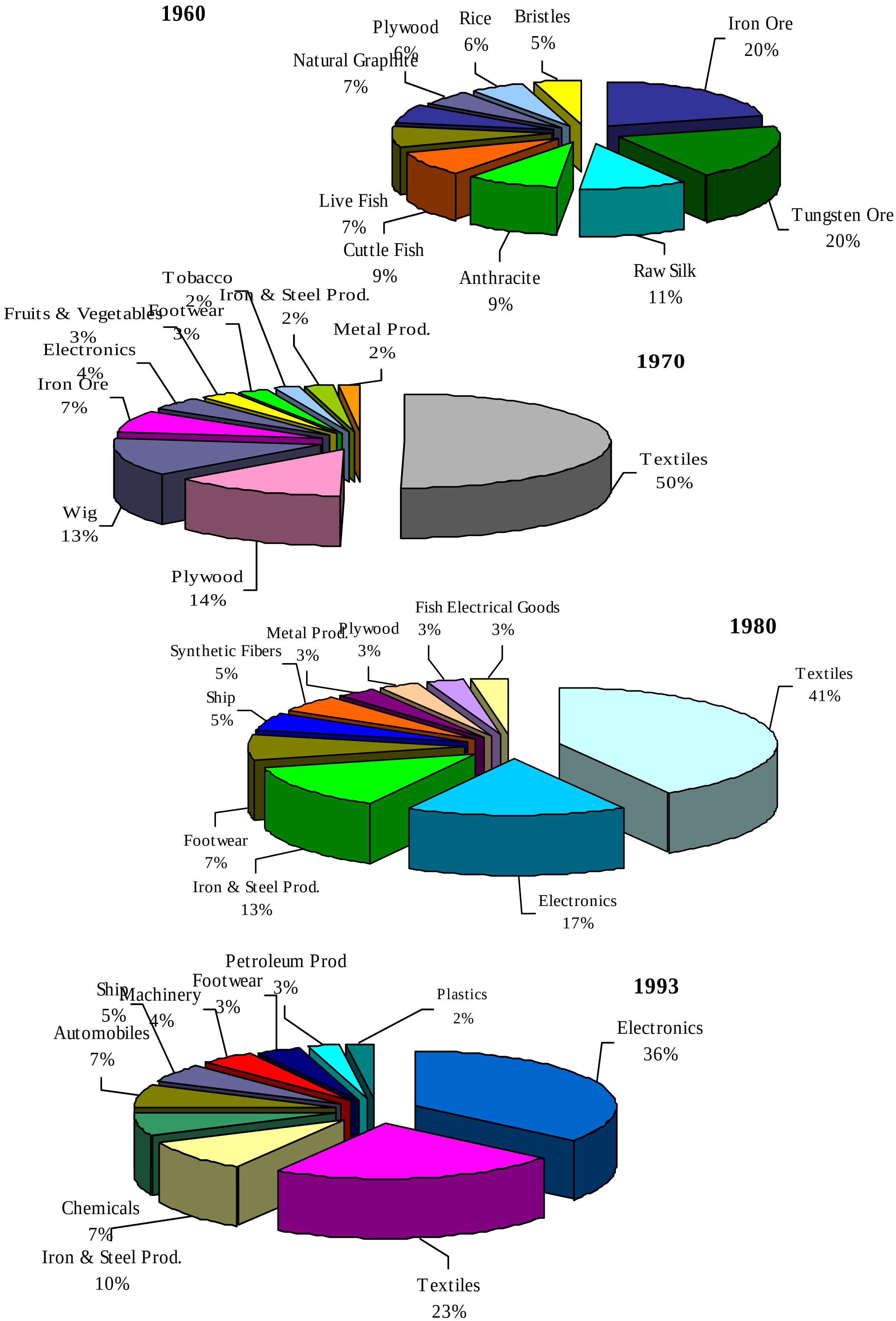
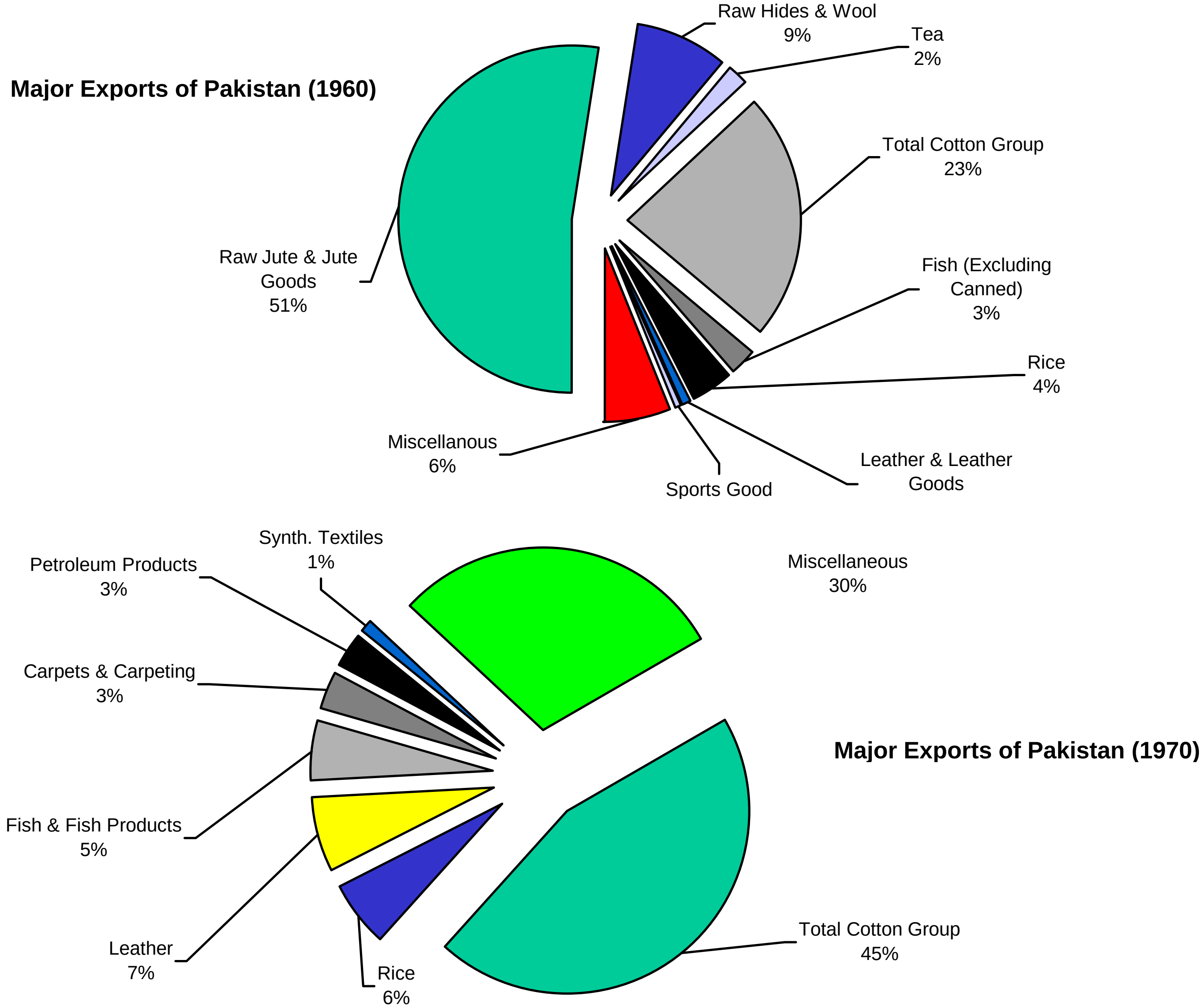


Figure - 8: Year Wise Diversification of Exports by S. Korea

Pakistan's exports of US$9.0 billion compare poorly with S. Korea's exports of US$142.0 billion (2001). Figure-9 shows the exports of Pakistan have not been diversified. On the contrary there has been concentration trend. Textiles comprise 63.5% of total exports out of which 60% is grey cloth and yarn instead of high value made-up textiles. During 1960-1971 Pakistan had 11% of the world market in textiles but today it is less than 2%. Pakistan is a major cotton producing country, but its textiles exports of US $5.1billion is three times less than those of S. Korea which exported textiles worth US $ 15.1 Billion in 1992.

"The structure of exports also indicates the level of technological development of a country, in particular the exports of engineering and other knowledge-intensive goods as well as the contribution of value added manufactures".

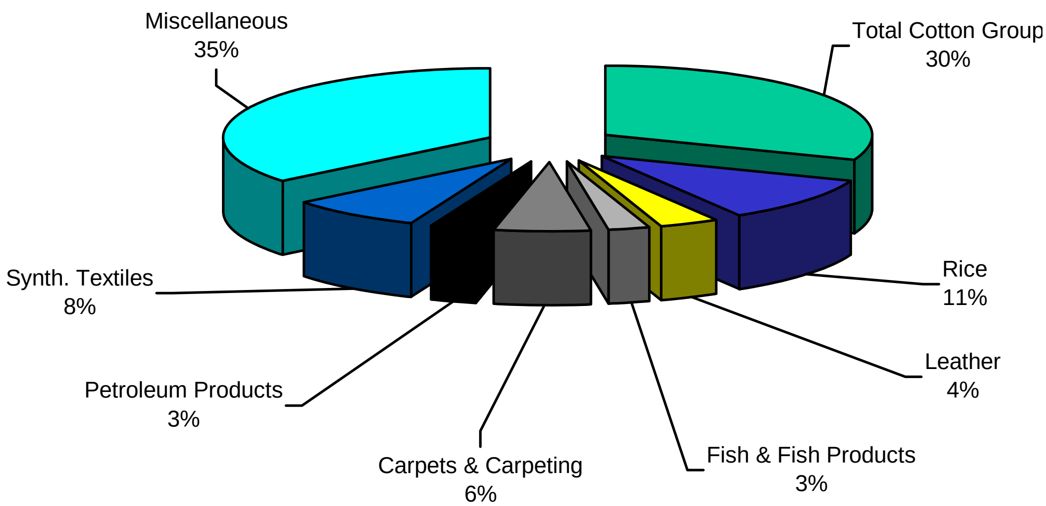
Pakistan spends almost $ 1.59 billion annually on the import of machinery and engineering goods. These include transport goods which comprise 19% of total imports. Despite building an over-capacity for production of engineering goods, indigenous production has been negligible.



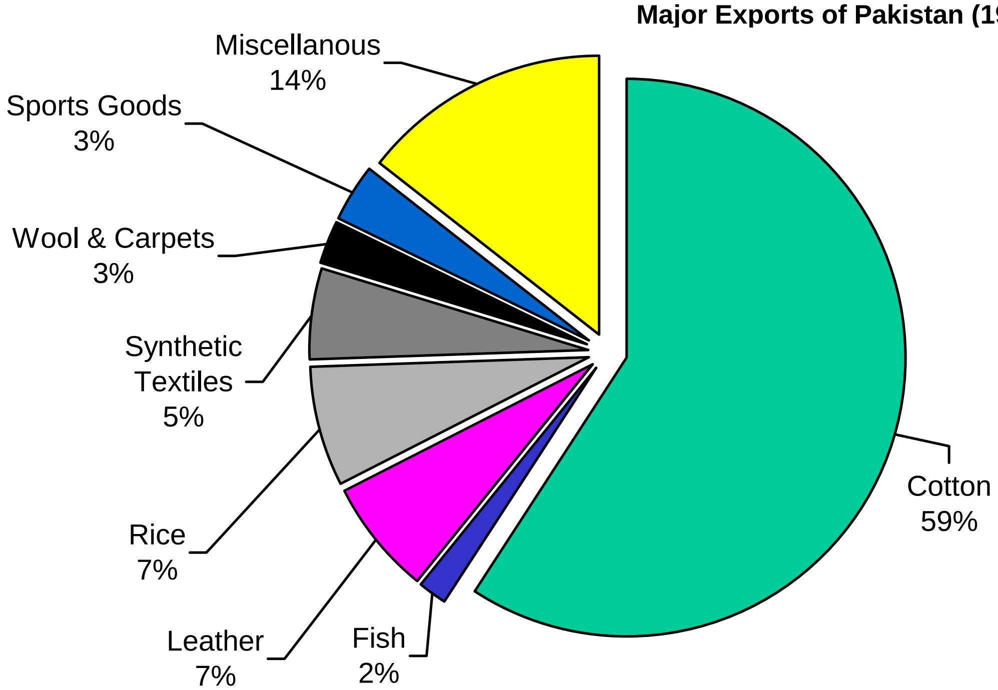
Source: Pakistan Economic Survey 1967-68, 1967-68

Figure - 9 (a)

Major Exports of Pakistan (1982-83)



Major Exports of Pakistan (1998-99)



Source: Pakistan Economic Survey 1983-84, 1999-2000

Figure - 9 (b)

The Deletion Policy announced in 1987 has helped in the assembly-cum-manufacturing processes of some of the engineering goods. Enterprises which opt for the deletion programme are provided concessionary import tariffs to import components/parts; the participatory enterprises are generally supposed to increase the use of local parts according to time schedule agreed with the deletion monitoring cell of the Government of Pakistan. Since the announcement of this policy a large number of small vendors have registered. This has helped indigenization of some of the engineering goods, particularly in the electrical, transport and electronic sector.

INTEGRATION OF S&T POLICY WITH OTHER SOCIO-ECONOMIC POLICIES

"Countries that do not have a well-defined and discriminating industrialization strategy have only vague S&T policies of a general supportive nature. They do not have strong policy instruments. The incentives and inducements offered, only encourage a general infrastructure for industrial S&T but are incapable of guiding the development of scientific and technological capabilities for industry. The converse is also true Countries that have defined an industrialization strategy, established priorities, and determined the scope and nature of government intervention have formulated S&T policies that correspond to the aims of industrial development". (Science and Technology for Development: Main Comparative Report on Science and Technology Policy Instruments Project, by Franciso Sagasti International Development Research Centre, Canada).

The former statement is true for S. Korea and the latter befitting Pakistan. Table No. 2 shows the integration of S&T policy with other socio-economic policies of S. Korea.

Table - 2: Interactive Development Between Industrial Policy and S&T Policy

	Industrialization	S&T Development
60's	•Develop import-substitution industries • Expand export-oriented light industries • Support producer goods industries	•Initiate S&T education • Construct scientific and technological infrastructure • Promote foreign technology imports
70's	•Expand heavy and chemical industries • Shift emphasis from capital import to technology import • Strengthen export-oriented industrial competitiveness	•Expand technical training • Improve institutional mechanism for adapting imported technology • Promote research applicable to industrial needs
80's	•Transform industrial structure to advanced and balanced form • Expand technology-intensive industry • Encourage manpower development and improve productivity of industries	•Develop and acquire top-level scientists and engineers • Perform national R&D projects efficiently • Promote industrial technology development
90's	•Promote industrial structure adjustment and technical innovation • Promote efficient use of human and other resources • Improve information network	•Realign national R&D projects • Strengthen demand-oriented technology development system • Internationalise R&D systems and information networks •Construct S&T infrastructure

Source: Science & Technology Policy Institute (STEPI), S. Korea

The Ministry of Science and Technology was established in 1967 as the central policy making, coordinating and promotional body of the government. In order to train high-level manpower for growing requirements of industry and research organizations, the S. Korean Advance Institute for Sciences (KAIS) was established in 1971 in addition to a number of existing universities and colleges.

KAIS provided post-graduate programs in applied sciences and engineering in selected fields to produce a core number of engineers and scientists. In addition, the changwon Technicians College was established to turn out high-calibre technicians who enjoyed similar pay scales and benefits as university graduates. This institution trained skilled workers to become master foremen in needed theoretical backgrounds and administrative skills. Many vocational and technical training institutes were established to meet the rapid, almost explosive demand for skilled workers and technicians[7].

The S&T Policy was closely articulated with the industrial policy. For example when S. Korea launched the National Research Development Project (NRDP) in 1984 and later HAN project in 1993, the Ministry of Trade, Industry and Energy (MOTIE) carried out a survey of industry to identify relevant projects. The HAN project aimed at development of strategic industrial technologies. Preferential funding was also provided to export-oriented industry[1].

For S. Korean products to compete in an increasingly competitive international market, it became essential for the private sector to conduct in-house R&D. The government provided soft capital to enterprises for technology development by creating financial institutions such as S. Korea Technology Advancement Corporation (K-TAC), S. Korea Technology Development Corporation (KTDC), S. Korea Development Investment Corporation (KDIC) and S. Korea Technology Finance Corporation (KTFC) were created[1].

KTDC was established as an autonomous public enterprise to promote R&D projects of industry. It shares both the risk of failure as well as the benefit of success and offers three different types of financial support: long term loans, conditional loans and equity investment. The major activities of KTDC include support for all aspects of introduction, improvement and adoption of advanced technology up to the commercialisation of R&D. It also provides special services in the areas of technology advice, feasibility studies for R&D activities, technology transfer and management.

Both KDIC and KTFC were established as Venture Capital Companies. They provide funds in the form of equity investment, acquisition loans and conventional loans.

During the 50s-60s Pakistan also adopted a private sector led, export-oriented policy, which resulted in GDP growth rate almost parallel to S. Korea. But wealth was concentrated in the hands of few and the social sector was neglected. After 1971, banks and major private sector industries were nationalized and an inward-looking, import-substitution policy was adopted. The import-substitution industries catered mainly to high-income strata of urban population. Inequalities in income distribution prevented the emergence of mass markets for manufactured goods. The predominance of agricultural and artisan activities, which were not fully integrated into the market economy and the existence of a large sector of population engaged in informal services in urban areas, limited the purchasing power of the majority of the population, preventing them from joining the market for industrial goods. The situation was further aggravated by the fact that industry was unable to generate adequate employment opportunity to absorb the increasing labour force.

The S&T policy followed in the last fifty years was also not integrated with other socio-economic policies. There has been little networking among stakeholders of the National System of innovation. The Technology needs of the various sectors of the economy were never defined and there have been no attempt on the part of the government to forge such linkages.

NETWORKING OF INDUSTRY, ACADEMIA AND GOVERNMENT

During the intermediate stages of industrialization (in S. Korea) the government encouraged private sector to set up formal R&D laboratories – the inducements included tax incentives, preferential financing for setting up new laboratories and exemption from compulsory military service. Thus, the number of corporate R&D laboratories increased from 1 in 1970 to nearly 2,270 by 1995 reflects the seriousness with which S. Korean firms were pursuing more technology intensive development. Most R&D personnel in corporate laboratories were hired among GRIs or S. Korean scientists working in universities and firms abroad. The financial incentive system included preferential interest rates.

In 1977 the government established the S. Korea Scientific and Engineering Foundation under the Ministry of Science and Technology. The government also founded the S. Korean Research Foundation under the Ministry of Education in 1981. These Foundations funded basic research in universities. The government also enacted the Basic Research Promotion Law in 1989 explicitly targeting university research as one of the top national technological priorities. As a result contract research between universities and industry increased from W 1.0 billion in 1975 to W 169.2 billion in 1990. The proportion of industry funded university research increased from 50% in 1975 to nearly 70% in 1970.

Table - 3: Networking of Industry-Academia –GRI Cooperation R&D

Networking	Manpower Cooperation	Non-Manpower Cooperation
Research Activity (Cooperative Research)	•Joint research in specific projects •Projects commissioned by private companies to universities and research institutes •Visiting researchers •Technology consulting to private companies	•Co-use research facilities •Exchange of technology information •Technology transfer •R&D cost sharing
Education Activity	•Exchange of professor and researcher -Professors lecturing at private companies -Researchers lecturing at universities Exchange of students -Field training at private companies - Researchers participating in the graduate course Industry's participation in training programs at universities	•Offering research facilities to universities (donation or allowance of free use) •Exchange of training materials and information •Providing scholarship (Private companies strategy to secure high-calibre manpower)

Source: Science & Technology Policy Institute (STEPI), S. Korea

Another important feature of the university-industry relationship was the emergence of technology based venture firms. One example is Madison. The founder of this company had a Ph.D. in electronics engineering and his four co-founders were graduate students at a laboratory that undertook research at KAIST on ultrasonic scanner technology. Madison in now one of the most dynamic ultrasonic scanner producers in the world accounting for 25% of global market in portable models.

In the wake of increasing demand for R&D by industry, the S. Korean government established specialized GRIs in important sectors of industry such as chemicals, biotechnology, systems engineering and aerospace to service the growing needs of the private sector.

In 1989 S. Korea introduced two major national R&D projects. The Industrial Generic Technology Development Project (IGIDP) and the National R&D Project (NRD). The Ministry of Trade, Industry and Energy (MOTIE) undertook a survey to identify urgent R&D projects in industry and offered financial support to GRIs and university laboratories to undertake projects jointly with private sector.

In the early 1980s the 15 R&D institutes were restructured to create 9 institutes. The basic reason for restructuring was to make individual research institutes reach critical mass quickly. The GRI's are now funded on project based system.

In Pakistan, over the years a large number of R&D institutions were created without creating a demand for their services in the production sector. Most of these institutions suffered due to lack of appropriate management structure, continuous funding, skilled manpower and other essentials for research. Linkage between universities, R&D organizations and the government are still not developed. Faced with the lack of demand for their services by the production sector, most of the R&D institutions originally designed to provide services to industry have gradually deteriorated. The skilled manpower has been leaving the country for better prospects in the developed world.

TECHNOLOGY TRANSFER POLICIES

Industrial technological capability can be built either through indigenous R&D or international technology transfer. Developed countries have followed the former model whereas S. Korea has followed the latter model. Foreign technology is often acquired through formal and informal means. The formal mode includes direct foreign investment and technology licensing while the informal mode encompasses a much wider spectrum such as imitation, training provided by foreign suppliers, studying abroad, importation of capital goods, out-sourcing and networking with foreign firms.

During the early stages of industrialization in the 1960s and 1970s, the informal mode was more important as channels of foreign technology transfer. In the 60s S. Korean firms found that trade related activities such as employers training abroad, technical assistance from suppliers of parts and raw material, and technical assistance from buyers were important modes of technology transfer.

It is important to mention here that during the early stages of industrialization, S. Korean companies allowed access by foreign companies to their market conditional to the transfer of technologies and the establishment of local R&D facilities and in some cases to joint research projects. Licensing contracts and Original Equipment Manufacture (OEM) arrangements were the main source of knowledge and expertise through which the S. Korean firms enhanced their core business capabilities (under OEM arrangements a local firm follows the foreign firm client's specifications/materials quality and design to produce goods that are sold under the buyers own brand name). Major clients in the automobile, electronics and semiconductor industries provided local producers with design and engineering support and blue prints.

Formal mode of technology transfer played an important role in the late 1970s. The growth of heavy and chemical industry in the late 1970s and 1980s was possible through the formal mode of technology transfer. Most of the technology in this period was imported through licensing and direct foreign investment. International sourcing and networking also contributed to industrial technology capability building. In the late 80s many S. Korean export industries graduated from the OEM strategy and started international marketing under Own Brand Name (OBN). Private companies began investing in research in the mid 80s. The number of corporate R&D Laboratories increased to 455 from 65 during this period and this trend continued in the 90s. Thus in 1994 there were more than 2000 corporate research laboratories.

Table - 4: Technology Transfer Policy in the 1960s

S. Korea	Pakistan
Industrial Development Targets	
- Development of Light Industries for Export - Building up base industries: fertilizer, refineries, fibre, etc.	-Industrial policy based on developing Private Sector -Import substitution. Building up an industrial base from indigenous raw materials mostly agro based industry.
Technology Required	
-Mature Technologies, Capital Imports	-Mature Technologies
Technology Transfer Policy	
-Earlier Stage (1962~1967): Relatively liberal policy for imports from developed countries. - Later stage (1968): Restrictive policy due to worsening Balance of Payment	-No technology transfer policy was formulated.
Major Modes of Technology Transfer	
-OEM, Capital imports, etc.	-Capital Imports/Turnkey Plants

OEM: Own Equipment Manufacturing.
Source: Science & Technology Policy Institute (STEPI), S. Korea
Economic Survey of Pakistan 1999

Table - 5: Technology Transfer Policy in the 1970s

S. Korea	Pakistan
Industrial Policy	
-Development of heavy Chemical and Engineering industries -Protection of domestic industries; Strategic industry-targeting policy.	-Import substitution, Nationalization of Banks and large consumer goods industries. -Protection provided to consumer goods industry. -Establishment of large industrial units under public sector.
Technology Required	
Mature technologies, Shift from Capital Imports to Technology Imports.	-Turn key plants/ Capital Imports. -Mostly obsolete Technology was imported
Technology Transfer Policy	
Restriction on DFI and FL.	-No specific policy -Technology transfer did not accompany knowledge transfer.
Major Modes of Technology Transfer	
-OEM -Capital imports -Technical training (as part of turn-key plant imports)	Limited reverse engineering.

Source: Science & Technology Policy Institute (STEPI), S. Korea
Economic Survey of Pakistan 1999

Table - 6: Technology Transfer Policy in the 1980s

S. Korea	Pakistan
Industrial Policy	
-Development of technology-intensive industries: electronics, automobiles, etc. -Policy readjustment from "protection" and "government-led industrialization" to "competition" and "private-led industrialization" - Liberalization of trade and investment	-Mostly import substitution, denationalization of agro based industry and some engineering units. -Grant of tax holiday for export industry, duty free import of raw materials and machinery for less developed areas. -Establishment of Export Processing Zone in Karachi.
Technology Required	
- High technologies	-Capital intensive technologies.
Technology Transfer Policy	
- Gradual Liberalization of DFI and FL	-No specific Policy. -Formulation of deletion policy.
Major Mode of Technology Acquisition	
-FL -DFI -Indigenous R&D	-From foreign sources. -Limited foreign investment.

Source: Science & Technology Policy Institute (STEPI), S. Korea
Economic Survey of Pakistan 1999

Table - 7: Technology Transfer Policy in the 1990s

S. Korea	Pakistan
Industrial Policy	
-Development of high-technology and knowledge based industries - Private sector-led industrial development - Liberalization of trade and investment - Protection of intellectual property rights	-Efforts towards privatisation of public sector industrial units:- -Exports of manufactured good comprising textiles and food products. -Establishment of Export Zones in other areas of Pakistan. Attempts towards liberalization and attraction of foreign investment. Intellectual property laws have been revised expect the plant protection law. Measures to strengthen MSTQ system
Technology Required	
- Core technology, High technology	-
Technology Transfer Policy	
-Globalisation of S&T - Liberalization of FL, DFI - Support of S&T exchanges, strategic alliances	-Technology transfer policy was approved but mostly remains un-implemented.
Major Mode of Technology Acquisition	
-Global sourcing - Strategic alliances - FL, DFI	-No institutional mechanism for sourcing technology. -Technology Information system is weak. -Strategic alliance only in limited areas of research. Capital Imports.

Source: Science & Technology Policy Institute (STEPI), S. Korea
Economic Survey of Pakistan 1999

CONCLUSIONS

Both Pakistan and S. Korea became independent about the same time. In the 1950s and 60s both followed private sector-led industrial policies. The direction of S&T policies in that period for both countries was to achieve economic growth through rapid industrialization. In order to help industry several important R&D organizations and universities were established to produce the requisite manpower for R&D.

However, the difference between the two countries was investment in human resources development and the general uplift of the social sector. Pakistan lagged behind on both fronts where as S. Korea's investment in human resource development and health resulted in lower population growth rate, equal distribution of wealth and relative political stability. The policies of indigenous capability-building helped expand the tertiary education programs and raising their quality. Building first-rate educational institutions required enormous financial and intellectual investment but this was considered an essential long term economic investment.

In Pakistan the nationalization of industry and the financial institutions after 1971 had an adverse effect on industrialization as private sector investment decreased considerably. The import substitution strategies led to the choice of more capital-intensive technologies and favored large-scale enterprises. The trade policy combined with the protectionist measures for enterprises discouraged demand for research in the production sector. R&D organizations as well as universities were also deprived of appropriate funding and effective institutional management. These strategies encouraged the use of imported technologies (mostly turn-key plants) and consequently domestic science and technology efforts could not make a substantial contribution towards economic growth in the country.

In contract, S. Korea adopted aggressive export-oriented industrial policies, which were backed by measures for creating a conducive environment for promotion of research and development activities both in the public and private sectors. The resulting expansion in export of value-added products provided the financial resources required to accelerate the rate of innovation and generate new and better paid jobs

S. Korea's S&T policy was geared towards encouraging innovation, technology-imports from foreign sources, reverse-engineering and technology development, building strategic alliances and above all technology diffusion at all levels of society. Through promotional measures which included the promulgation of several laws/ordinances and through tax incentives to the private sector, S. Korea created the pre-requisites for technological development. This integrated approach allowed the creation of a nexus between technological, managerial, organizational and institutional upgrading and the overall economic and social development processes.

In the case of Pakistan, each five year development plan acknowledged the need for linking S&T efforts with industrialization strategies and in turn with the economy but there was no concerted effort by the respective ministries to forge linkages. The S&T effort therefore could not benefit the production sector.

The integrated approach adopted by S. Korea supports the notion that economic performance depends on the establishment of self-reinforcing relationship among education, R&D and learning, the principal activities leading to the expansion of knowledge base, innovation processes, productivity growth and international trade.

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PLANNING FOR SUSTAINABLE DEVELOPMENT

*Tajammul Hussain**

INTRODUCTION

The need for collective efforts by developing countries, faced with multifaceted challenges both at national and global frontiers, to succeed against the changing scenarios, is no more in question this century. The imperative lies in addressing all three, namely social, economic and environmental issues of development, simultaneously, in the face of emerging economic globalisation, formation of common markets and changing political-economic imbalances at the international horizons for sustainability.

If we look in the past, the developing countries have been focusing mainly on one of the issues for development, yet discounting the rest. One true example is Pakistan that has engaged itself in pursuing policies for enhancing economic activity and, on the other hand, the investment in social sector had been discreditable, with less than a meagre 2% of national budget allocated for education.

'Sustainable development' implies a "win-win" situation, whereby all the issues of development are addressed concurrently. The basic factors of production---man, machine, material, and money---all have to excel in terms of quality and quantity, the better the input the better would be the output.

Taking a brief view of the global scenario (see Fig.1) the developing countries are set with even more difficult developmental targets than before, with ever-growing population, increased poverty, unstable economies, and depleting natural resources.

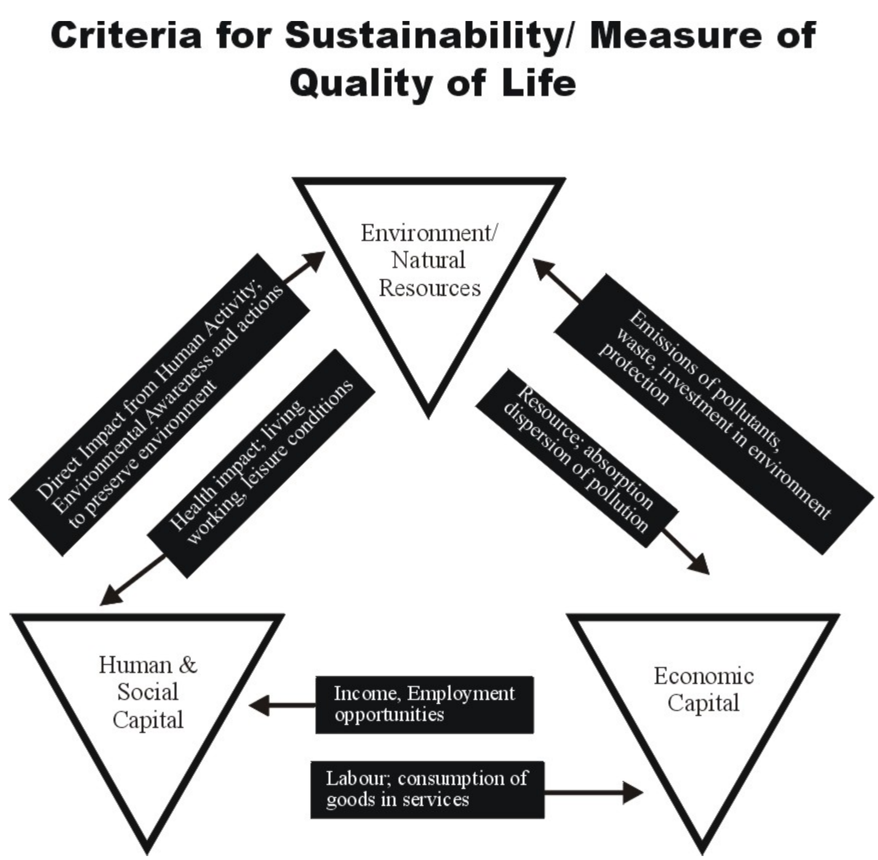

Figure - 1

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Population

Setting goals to reduce poverty is an essential part of the way forward, for which developed as well as developing countries have to make concerted efforts. Although the baby boomers' era has long passed, but its affects are being realized now and in the time to come. The world-population more than doubled in the last half century (see Fig. 2) and reached 6 billion in late 1999. It is projected that all the growth will take place in today's developing countries and that the world-population will grow by 50 per cent from 6.1 billion today to 9.3 billion by 2050. The least developing countries will nearly triple in size.

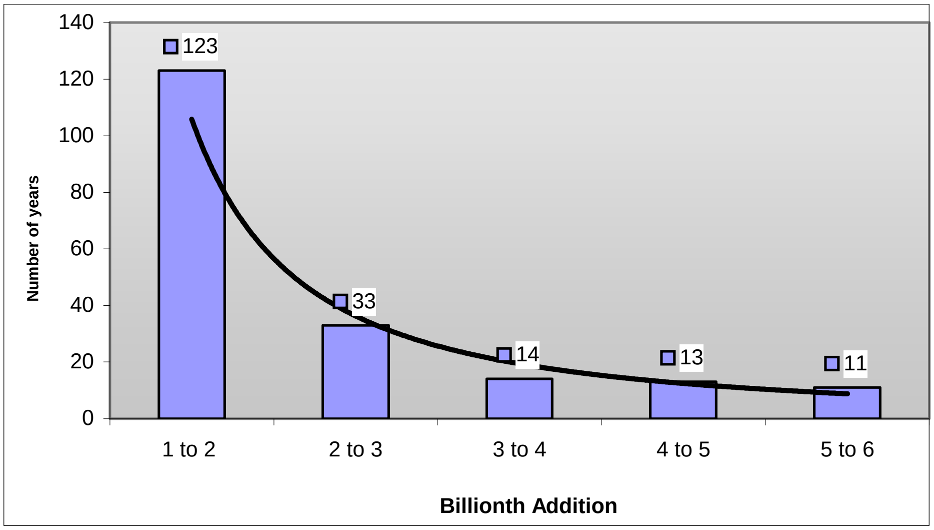

Figure - 2

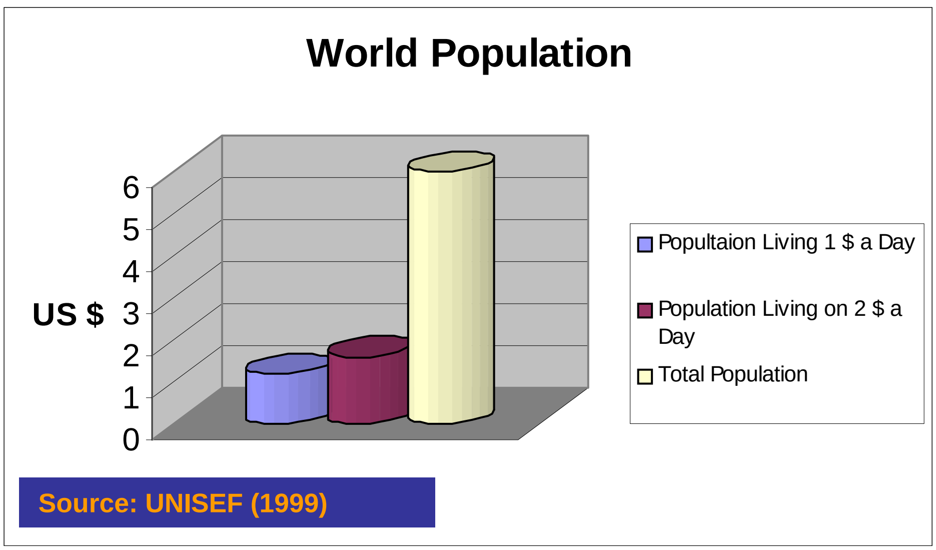

Figure - 3

Poverty

Poverty in all its forms is the greatest challenge to the international community. Of special concern are the 1.2 billion people living on less than $1 a day and the additional 1.6 billion living on less than $2 a day (see Fig. 3 and Table 1).

Illiteracy

Illiteracy and unawareness are both cause and consequence of poverty and population -growth is another major challenge, confronting the developing world. Nearly one-sixth of the world cannot read or write. More than half of those denied educations are girls, UNICEF, the United Nations children's fund, says in its annual report, "The State of the World's Children 1999:" Apart from deepening divisions between rich computerized societies and those without even the elementary tools of knowledge in the third world, illiteracy has a direct relationship to important social-indicators like health. An overwhelming percentage of illiterates are in countries with high population-growth, like India and Pakistan, where better education for women and children could significantly reduce other problems.

Table - 1

Population Living Below US$1 Per Day in Developing Countries 1990 and 1998				
	Number of People Below US$1 A Day (millions)		**Poverty Rate (%)**	
	1990	**1998 (estimate)**	**1990**	**1998 (estimate)**
East Asia	452.4	278.3	27.6	15.3
Excluding China	92.0	65.1	18.5	11.3
South Asia	495.1	522.0	44.0	40.0
Sub-Saharan Africa	242.3	290.9	47.7	46.3
Latin America	73.8	78.2	16.8	15.6
Middle East/N.Africa	5.7	5.5	2.4	1.9
Europe & Cent. Asia	7.1	24.0	1.6	5.1
Total	1276.4	1198.9	29.0	24.0
Source: World Bank. Global Economic Prospects and the Developing Countries 2000. (2000) [1].				

Food Insecurity and Malnutrition

In 1990 a total of 780 million people out of 4 billion, in the developing world, were living on diets that are not sufficient to maintain a healthy life, according to the Food and Agriculture Organization (FAO). This implies food-insecurity for every fifth person in the developing world. Insufficient food-consumption is one of the primary causes of malnutrition; the others are infection and poor health. The nutrition situation-reports found that protein-energy malnutrition (PEM), measured by the proportion of children falling below the accepted weight standards, affects 34 percent of all preschool children in the Third World. Another study shows that PEM, even in its mild-to-moderate form, contributes to 56 percent of child deaths in 53 developing countries, suggesting that malnutrition has a far more powerful impact on child-mortality than is generally believed.

Health

In addition to Protein-energy Malnutrition, insufficient food-consumption leads to other problems that are of public-health significance. Every year, 250,000 to 500,000 children go blind due to vitamin-A deficiency. Estimates by Marito Garcia, a world-bank economist in a brief "Malnutrition and food insecurity projections, 2020" quoted Administrative Committee on Coordination /Sub Committee On Nutrition(ACC/SCN) that in 1990, 370 million women between 15 and 49 years of age were anemic, a condition that contributes to high maternal mortality-rates, especially during childbirth. A recent assessment by WHO indicates that some 655 million people in the developing world are affected by goiter. This figure is nearly three times the previous estimates.

Depleting Natural Resources

Developing countries have long been depending on the factor-endowments for sustainable growth and development, especially the oil-rich Arab countries, but there should be no doubt in any one's mind that these resources shall come to an end. Accordingly, sole reliance on the factors of endowment does not respond to the challenges ahead.

Lack of Basic Amenities of Life

According to a study by the International Water-Management Institute (IWMI), nearly one billion people may not have access to water by the year 2025[2]. The study projects the water supply and demand pattern across 118 countries and concluded that 25% of the world's population or 33% of the population of developing countries live in the region that will not have sufficient water to maintain the 1990 level of food-production from irrigated agriculture.

ISSUES AND CHALLENGES

In addition to the problems at the national level, the developing countries' governments are faced with even more acute complexities at the international or global level.

Globalisation

Economic "globalisation" is a historical process, the result of human innovation and technological progress. It refers to the increasing integration of economies around the world, particularly through trade and financial flows. Mostly, globalisation is termed with a meaning of trade, movement of people, capital movement and spread of knowledge.

Whereas economic globalisation has had a positive impact in integrating the world with more choices, it has a flip side to its credit too. Globalisation has been the cause of unparalleled growth and increased inequality, mostly benefiting the industrial world with strong infrastructure for export and production; so the gaps between rich and poor countries, and rich and poor people within countries, have grown. The richest quarter of the world's population saw its per-capita GDP increase nearly six-fold during the century, while the poorest quarter experienced less than a three-fold increase, according to one analysis.

Countries must be prepared to embrace the policies needed and, in the case of the poorest countries, may need the support of the international community and interdependence to endure the consequences of globalisation.

Trade Liberalization

The effects of trade liberalization has been overtly realized by the developing countries with its effects in form of reduction in government control and revenues, trade deficits, wage and income inequality, the threat to national sovereignty, environmental pollution, and health and safety of common man. With expected opening up of markets by 2005, the situation tends to worsen for the trade-partners with no or modest infrastructure for production, unskilled labor, outmoded technology and specially depleting natural resources, in brief, the developing states.

Transnational Corporations' Hold on World Economy

The emerging global order is spearheaded by a few hundred corporate giants, many of them larger than most sovereign nations. For example, Ford's economy is bigger than that of Saudi Arabia or Norway.

By acquiring earth-spanning technologies, by developing products that can be produced anywhere and sold everywhere, by spreading credit around the world, and by connecting global channels of communication that can penetrate any village or neighborhood, these institutions we normally think of as economic rather than political, private rather than public, are becoming the world empires of the 21st century.

The Transnational corporations exert a more profound influence on the lives of the people of the world than national government who are increasingly finding it difficult to comprehend, still less control, these corporate giants.

Widening Gap Between Rich and the Poor

Globalisation and trade-liberalization have not turned the tide against poverty, as projected in early yester-century. In fact the gap between rich and poor countries as well as wealth-disparities within countries have increased. The UN Human Development Report shows that the rich have become richer, while the poor have become poorer. In 1960, 20% of the world's richest earned 34 times more than the 20% of the world's poor. In 1997, it was 74 times more! The assets of the three richest people in the world are worth more than the GDP of the 48 least developed countries. The net worth of the 200 richest people has increased from $440 billion in 1994 to 1 trillion in 1998.

It has been acknowledge that all the major targets set to reduce poverty have failed. Furthermore, the notion that export-led growth is the answer has failed. Not only are the poor worse off in most developing countries, but globally the rich are getting richer and more powerful.

Widening Digital Divide

The industrial countries cherish economic growth on the thrust of their knowledge-based society; whereas one of the main causes of third-world distress lies in their incapacity due to fragmentation and isolation of research institutes and academia. The divide between developed countries' knowledge-based society and developing World is due to disintegration and individual efforts by knowledge-centres. The digital divide is one of the many reasons for the developing nations' inability to cope with present-day problems.

FRAMEWORK TO FACE THE CHALLENGES

As the developing countries are confronted with greater problems, the urgent need arises for them to plan comprehensively, so that they should address all the issues and challenges, concurrently, and to strategize for the shortest, most effective, and reliable way out to sustainable development.

"Sustainability" implies a win-win situation in all areas, hence sustainable development means enhancement and better utilization of economic capital, human capital and natural resources, concurrently and effectively, but not on each others' cost. The planning for sustainable development should therefore entail these aspects for durability, to not only relish benefits of today but to ensure safe and promising future.

The problems are common to all the developing countries and therefore a common framework can be adopted to find a solution. The options that developing countries have are very clear: the question for uniting against the forces of change and socio-economic problems, the close cooperation in all spheres of life with science and technology as the tool for achieving sustainability in the development process.

Science and Technology as 'Rescue Agent'

With science and technology bringing revolution in all spheres of life, changing the way we socialize, communicate, work, commute, produce & consume and entertain ourselves it is going to work as change-agent in the lives of both developing and developed nations. As we are all aware, change, competition, and complexity will be the feature of modern era in a world increasingly dominated by science and technology. Science and technology is progressing faster than before, and nobody will be able to master and handle it alone. Therefore we must share information, knowledge and expertise, funds and facilities. The normal ethics of science and technology must guide every endeavor for the benefit of mankind. In the 21st century; industries will be more technology-intensive and human society increasingly knowledge-intensive. Therefore, science and technology will assume an increasingly crucial role and it can prove to be the ‘Rescue Agent’ for the developing countries.

Through science and technology, the developing countries can shield themselves, with the global problems uprising rapidly, and can avert the challenges at national level, whether social, economic or environmental. Science and technology bears great potential in addressing the issues and challenges confronting the Third-World and can contribute immensely towards taking out itself from the projected economic and social havoc.

The Way Out

Science and technology is the key to sustainable growth and development and there is no denying the revolutionary powers it possesses in the form of information technology, biotechnology, such that, the future trade and commerce and economic growth would largely depend on the applicability and utilization of information technology. Information technology is a means to cheap and accessible information and education for all.

Research done in the field of Biotechnology up-till now empowers the scientist to address horrifying forecasts for food insecurity, health and malnutrition. The use of depleting natural resources for energy production can be optimised with supplement of renewable-energy technologies, like photovoltaic, thermal, wind and geothermal technologies.

The Newly Industrialized Economies (NIE) like South Korea and Malaysia are good archetype, their efforts and initiatives can be bench marked to pursue the path of sustainable development.

Where Do We Need Planning?

The need of the hour is to identify the areas that need planning. First of all, taking a look at the present status of science and technology in the developing countries, we find out that the developing nations are good at some fields of science and technology and lack expertise in others, mostly working in isolation. Secondly, the infrastructure required for proliferation of science is far behind the international standards; thirdly, the developing nations need capacity-building in the key-areas of science to make proper use of technology.

Most of the developing countries have agriculture-based economies, and the economies thrive on the status of yearly yield. With the usage of science and application of technology, the crop cannot only be salvaged from external threats, but also the yield can be raised. Usage of agro-sciences can help the economies to achieve higher levels of sustenance. After achieving the higher level of sustenance, the economies transform and can broaden the base for growth and progress, through other industries.

The number of scientists per thousand people in the developing countries range mostly from 0.1 to 1, whereas the industrialized nations have figures in the range of more than 2 to 3 persons per thousand. In addition, the developing countries have failed in retaining the critical mass that move to developed countries, for better returns.

SCIENCE AND TECHNOLOGY ISSUES IN THE DEVELOPING WORLD

Although the challenges and issues are common to the developing world but, due to disparities in their economic and technological state of development, the key-issues regarding science and technology need to be identified at national and regional level for proper strategizing.

NATIONAL LEVEL

Cooperation, Coordination and Interaction. Communications and interaction between the technology and user sectors are important in deriving maximum benefits for any technology-application efforts. This is also true for the S&T sector, where there is a need for agencies/space centers, research and development (R&D) organizations, end-users, industry, universities, planners and decision-makers to cooperate closely on various aspects viz policy formulation, programming, planning and implementation of S&T projects.

Human Resources Development: Science and technology are dynamic and the need to develop human resources is growing continuously. Training and education of scientists, as well as end-users, are required in the important sectors like that of natural resources and the environment, telecommunications, meteorology, survey and cartography, agriculture, water resources, urban planning, geology and mineral exploration, forestry, oceanography, disaster-warning and relief.

Resistance to Change: There is a general resistance to change in the institutional structure and to the introduction of new technologies. Better management-techniques, in-service training and education of professional staff and their career-planning would be important in curbing this tendency.

Lack of Awareness: Lack of awareness of the benefits to be obtained from applications of science and technology may constitute a serious limitation at the national level in promoting these applications. Therefore, promotional efforts are necessary, at the national level, to raise awareness of the benefits of such applications.

Adoption/Adaptation of Technologies: There is a need for adoption/adaptation of technologies, imported from abroad, to suit the social and cultural environment of the countries.

Rapid Technological Developments: The field of science and technology is in a state of rapid development. To develop applications from this rapidly evolving technology is therefore a highly challenging task.

Involvement of the Private Sector: The private sector needs to be involved in S&T applications, as well as in the development and production of related hardware and software, and value-added information.

REGIONAL AND INTERNATIONAL LEVELS

Regional Cooperation: The success and achievement in regional cooperation in S&T applications promoted have been convincing. The continued promotion of substantive cooperation, coordination and collaboration among the countries' regional programme is considered essential.

Closer Cooperation with Existing Initiatives: It is recognized that there are a number of well intentioned initiatives for regional cooperation in S&T applications in the South. Therefore, in the larger interest of the region, the need for a study for their coordination through the regional programmes is considered important.

Resource Mobilization: There is need for a regional effort to mobilize resources, both in cash and in kind, as well as for substantive activities on S&T for development in the region.

Interaction: The need for enhancement of interaction between Governments, various agencies in the United Nations system, and entities such as the end-users, NGOs, and industry, in the fields of science and technology applications, is recognized. This will give great impetus to the national and regional S&T applications programmes.

Human Resources Development: There is a need for regional assistance for the training and education of scientists, technologists, users, decision-makers and planners in various facets of S&T for the development of indigenous capabilities in the countries of the region. The facilities and expertise available in the region could also be usefully harnessed.

Restrictions on the Transfer of Technology: Restrictions on the transfer, from North to South, of technology and information regarded as "sensitive" or of "commercial value" frequently limit the domain of applications of science and technology.

ROLE OF COMSATS IN PROMOTING SCIENCE AND TECHNOLOGY FOR SUSTAINABLE DEVELOPMENT

The establishment of the Commission on Science and Technology for Sustainable development in the South (COMSATS) was envisaged, keeping in view the identified issues in the field of science for sustainable development. The objectives and functions incorporated in the mission-statement highlight the scope and direct the path towards development, as:

- To sensitise the countries of the south to the centrality of science and technology in the development process, to the adequate resource allocation for research and development, and to the integration of science and technology in the national and regional development plans;
- To support the establishment of a network of international science and technology centers of excellence for sustainable development in the south;
- To support other major initiatives designed to promote indigenous capacity in science and technology for science-led sustainable development, and to help mobilize long-term financial support from international donor-agencies and from governments /institutions in the north and the south, to supplement the financing of international scientific projects in the south;
- To provide leadership and support for major North-South and South-South cooperative schemes in education, training and research, such as the proposal to set up programs of scholarships for research at centers of excellence in the South;
- To support the relevant programs and initiatives of major scientific organizations working for the development and promotion of science and technology in the south.

The cooperation amongst the developing countries in the field of science and technology would not only be economic, but also a shield from the vested interests of the developed countries. In light of the science and technology scenario, some suggestions and recommendations are made to attain sustainability in the development process:

1. *Sensitise to the Centrality of Science and Application of Technology:* This necessitates sensitising the countries in the south to the centrality of science and technology in the development process, both in public and private sector, to foster awareness regarding the application of science and technology to meet various present-day challenges;

2. *Establish Centres of Excellence:* Establishment and strengthening a network of Centres Of Excellence i.e. research organizations, knowledge-imparting institutes;

3. *Cooperation in Capacity Building:* Indulge in providing cooperation schemes in education, training and research for capacity-building;

4. *Combined Research Projects:* Undertaking combined research, both in basic and applied sciences;

5. *Support Developmental Programs:* Support the relevant programs and initiatives of major research organizations and working for the development and promotion of science and technology.

6. *Articulate Objectives and Develop Implementation Mechanism:* An analysis of the national S&T programmes in the region indicates that a clearly targeted objective, an appropriate implementing mechanism and the necessary institutional structure are the three fundamental elements for the success of national programmes. The strategy for developing science and technology for sustainable development should cover these three fundamental elements, as well as technological cooperation, financial mechanisms, legal arrangements and human resources development programmes.

7. *National Mechanism to be Responsible for Coordination and Promotion:* On account of the multi-disciplinary and inter-sectoral nature of S&T applications, it is desirable that a national mechanism should be made responsible for the coordination and promotion of S&T applications and their integration with national development.

8. *National Committee for Science and Technology:* Such a mechanism could be named as the national committee for science and technology in the national development programmes. Its secretariat should be located in the same ministry. The head of the national committee should be a member/secretary of the committee and in that capacity provide, to the secretariat, all the necessary expert-advice on science and technology matters. Other members of the committee should be at the permanent-secretary level, from the ministries of education, finance, planning, agriculture, environment, forestry, mineral exploration, urban and rural development and telecommunications. The committee may also have sectoral experts, as technical advisers, in areas such as agriculture, water-resources, cartography and surveying, meteorology, disaster-management and relief. In addition, it may have advisers from the universities, consultancy-firms and private-sector industry, especially those which are already engaged in science and technology activities or have the potential to do so in the near future.

9. *National Action Plan:* The committee could be responsible for drawing up national action plans, say for five-year periods, identifying the problems to be addressed through science and technology and the resources required to implement the plan. It will ensure coordination and implementation of the action- plan and monitor its progress. It may also decide on the composition of the national delegations to regional and international meetings on applications of science and technology. It may also provide overall policy-guidelines and directions to the national focal point.

10. *User Groups to be set up:* Various user-groups may be set up in respective fields of S&T applications, to provide enlightened and down-to-earth inputs for linkage of science and technology with the solution of national problems. A link with provincial-level ministries and national and provincial-level departments, dealing with these sectors, should be ensured through such groups.

11. The user groups could assist the respective ministries by providing them with information and suggestions based on their expertise. They could also advise on the implementation of the national initiative that aims to enlarge the base of science and technology users. The precise partnership between the user-groups and the national committee for science and technology applications, under the national action-plan, could be determined through close consultations between the two. The role of each entity should be determined in such a manner as to maximize their comparative advantages. For this purpose, the user-group of each Sector might even propose its own specific projects, in support of the national programme.

12. The national science and technology centre and universities (especially those having science and technology) might encourage the popularisation of S&T applications for addressing national problems and the integration of S&T techniques with developmental planning, through the organization of seminars, workshops, discussion panels, demonstrations, lectures, publications, newspaper articles, radio and television programmes. This activity would develop public awareness of the potential of science and technology. Further, it would provide feedback on the effectiveness of the national action-plan, which could go directly to making improvements and the requisite adjustments.

Human Resources Development

13. *Human Development Policies:* This serves the dual purpose of stimulating economic growth and social development. It also has close links with technological change. Human-resources development-policies should therefore be coordinated with those of economic and social development. In the context of science and technology and applications, it is proposed that selected national universities should offer courses, at Postgraduate level, in science and technology. Bearing in mind the application-dimensions of the technologies, these courses should not only focus on theory, but also emphasize the practical applied dimensions. This will enable the education of the requisite number of scientists and engineers at the postgraduate level, over time, to meet the requirements of the expanded national science and technology programme.

14. *Integration of Technologies into the Development Process:* Moreover, in developing human resources for S&T applications, adequate emphasis should also be placed on the integration of technologies into the development process, as such integration calls for harmonized development: between

hardware and software (technical aspect) and the human element and "Orga-ware" (institutional aspect).

15. *Joint Ventures with Foreign Firms:* Concurrently with human resources development-programmes, the alternatives for technological change should be explored. These should include the assimilation of imported technology, indigenous innovation, and joint-ventures with foreign firms and entrepreneurs, in the development of equipment and software for applications of S&T in the national development process. Public and private-sector industries may be encouraged to develop ancillary products for commercial use, through technology transfer in the S&T applications field.

16. *Long-term Career Planning:* Careful planning of the long-term careers of scientists and technologists, establishment of adequately equipped R&D laboratories, the creation of the proper environment, conducive to scientific work in laboratories, would all go a long way to retaining qualified and trained individuals in their countries of origin and also provide creative job-opportunities to those returning from abroad, after obtaining high qualifications. This approach would arrest the brain-drain taking place from the developing to the developed countries.

17. *Specialized Training:* To put the persons with specialized training and education to optimum use, they should be retained in the job for which they were trained or educated, for a sufficient length of time, to enable them to perform specialized duties and train others according to future needs. The training opportunities provided by international organizations and others, in the form of fellowships, workshops and seminars, should be used to train and educate the maximum number of persons. Prompt processing of the nomination of candidates for such activities should be encouraged, keeping in the forefront the objective of widening the base of knowledgeable users.

18. *Grant Autonomy to S&T Institutions:* Some of the steps necessary to make the environment conducive to productive scientific work are to grant full autonomy to the universities and R&D organizations, allow scientists to go through continuing-education programmes and encourage the movement of scientific and technical staff between universities, private-sector industry, public-sector industry and R&D establishments, to broaden their vision, promote interaction among these entities and lift isolation barriers.

19. *Upgrade Technical Skill:* Another important element for the successful introduction of any technology, which is high technology, is to upgrade the technical skills of the existing staff so as not to render them redundant upon the introduction of such technologies as require a high level of skills, like the use of computers and the development of software packages. The national applications centre, either on its own or in collaboration with the universities, should organize continuing-education programmes for its staff on a regular basis.

20. *Provision of Basic Infrastructure for Cooperation:* For cooperation and information-sharing to develop knowledge-intensive societies, the paramount task in this goal would be to first understand the need and status of each other to reduce the information gap, for which information-technology provides the information-vehicle, in form of information highways, information communication technologies.

21. *Science education at Early School Level:* Science education should be imparted at the early school level, so that children can mentally adapt and adopt the aptitude required to be good scientists and researchers. It would help them in deciding their future at an early stage of their life.

22. *Broaden the Base of Science Capital:* The science education should not only be in general basic disciplines like physics, chemistry; rather, further divisions and branches of various fields of science should be entailed in the curriculum, to produce human capital with diverse disciplines, following the wise saying "not to put all the eggs in one basket".

23. *Vocational Training:* Vocational training needs to be included as a compulsory ingredient in the overall educational system, so that students can assess their academic weaknesses at the high school and college and adjust in time for greater responsibilities.
24. *Expert Exchange Programs:* Expert-exchange programs should be promoted aggressively, for

orienting the work-force with a broader perspective, and to benefit from foreign expertise in the field, this is essential for developing countries specializing in a particular field.

Research and Development

25. *R&D Spending:* Scientific R&D is a prerequisite for building indigenous capability. In several countries of the region, one may find large numbers of R&D organizations, but with little or no money for undertaking R&D – the purpose for which these organizations were established in the first place. The allocations for R&D in most of the developing countries of the region may vary somewhere around 0.15 per cent of gross national product, (GNP) depending on the country. Under these conditions, for satisfactory results, it would be necessary to concentrate only on a few selected areas of R&D at a time, so as to avoid spreading the limited resources of scientific staff and funds too thinly. Further, the allocations for R&D should be raised to at least 1 per cent of GNP, to be able to deliver discernible outputs.

26. *Optimise R&D Efforts:* The countries of the region, beginning R&D activities in S&T programmes, may concentrate on one or a few particular S&T applications. Cooperation, between these countries and those with already advanced R&D activities, would contribute to optimising R&D efforts in trying to solve common problems in the region.

27. *Emphasis on Basic Research as well:* Research in both basic, as well as applied sciences, needs support; basic research should be supported much more for long-term gains.

28. *Information Services:* As is true for any planning or development activity, it is essential to back up science and technology projects with adequate information and data required by the project team, so that these are completed without undue loss of time and with the least expenditure. The more reliable and exhaustive the information on a project, the better it will be for the success of the project. There are numerous cases of a country seeking transfer of technology from abroad, even when the same technology is already available within the country. Such a situation arises on account of the information-gap in the country, which results in loss of national resources and waste of time. In addition to establishing and operating a computerized database, the national representative should develop national documentation centers on S&T applications-related books, magazines, research papers and project-reports, to serve the needs of national and international users. Such facilities, though on a limited scale and sectoral in character, should also be developed in each major applications user group.

Resource Allocation

29. It is always difficult to introduce a new technology. This is especially true for the emerging field of science and technology for development planning. The financial aspects related to the introduction of this technology must be analysed carefully, in order to convince the decision-makers and planners of its benefits. Resource optimisation could be achieved by utilizing the scientific and technical staff and facilities of existing national R&D organizations. Cooperation among the countries of the region would also assist in reducing the cost of launching and implementing a space-applications programme at the national level. Some of the countries of South already have an established base for development and applications of science and technology. A number of these countries may have sufficient capacity in relevant S&T fields.

30. *Utilization of Existing Resources:* Utilization of existing resources in the establishment of national committees and user groups, through appropriate restructuring and opening up of the national R&D facilities. However, there is still a need for additional funds:

    a. To establish science and technology applications-related academic programmes at selected universities;
    b. To augment the facilities of S&T applications centres with the necessary additional hardware and software;
    c. To enhance the capability of national focal points; and

d. To develop documentation centres, including library facilities, with the sectoral user groups.

The importance of science and technology for addressing national and regional problems, and their becoming an essential element in sustainable developmental planning, will keep growing with time. Investments made in capacity-building for increasing the domain of applications of scientific techniques are expected to yield rich dividends. In fact, these may determine whether a country joins the ranks of the developed countries or remains in the class of developing countries.

The issues and challenges that are global in nature should be addressed concurrently and through proper exploitation of science and applications of technology, which encompass the much-needed potential to achieve and maintain sustainability. Social, economic and environmental problems are interrelated in a way and the development engines, of the like of, information technology can avert the projected horrifying scenarios, but the impetus lies in proper management of science and technology, with revolutionary powers that can turn the tide of developing countries as well as developed nations. For science and technology to play its due role in development, key-issues in developing countries regarding science and technology need to be tackled that need planning and cooperation at national, regional and international level.

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IMPACT OF BASIC SCIENCE ON ECONOMIC DEVELOPMENT

*Hafeez Hoorani**

ABSTRACT

In this presentation, the role of basic science in the economic prosperity is emphasized. A number of examples from the past are given where a discovery in fundamental science has led to a major economic development. Even the industrial revolution of the 17th century had its origin in basic science. Funding basic science should be the responsibility of the Government and not that of an individual or a group. The benefits of basic science are long-term and unpredictable, so in general one cannot expect a return in the short-term.

INTRODUCTION

Our lives are enriched, and our outlook changed, by (e.g.) knowledge of the heliocentric system, the genetic code, how the sun works, why the sky is blue, and the expansion of the Universe. The point was elegantly, if arrogantly, made by Bob Wilson (first Director of Fermilab, a large particle physics/accelerator laboratory near Chicago) who, when asked by a Congressional Committee *"What will your lab contribute to the defense of the US?"* replied *"Nothing, but it will make it worth defending".* A number of scientists would like to defend the basic sciences without any practical applications, at least in the beginning; and this is a very ancient phenomenon, as shown by the following dialogue in Plato's Republic:

Socrates: "Shall we set down astronomy among the subjects of study?"

Glaucon: "I think so, to know something about the seasons, the months and the years are of use for military purposes, as well as for agriculture and for navigation."

Socrates: "It amuses me to see how afraid you are, lest the people should accuse you of recommending useless studies."

In this paper I shall argue that the search for fundamental knowledge, motivated by curiosity, is as useful as the search for solutions to specific problems. The reason we have practical computers today, and did not have them 100 years ago, is not that meanwhile we have discovered the need for computers. It is because of discoveries in fundamental physics, which underwrite modern electronics, developments in mathematical logic, and the need of nuclear physicists in the 1930s to develop ways of counting particles. I shall cite many examples, which demonstrate the practical and economic importance of fundamental research. But if fundamental, curiosity-driven, research is economically important, why should it be supported from public, rather than private, funds? The reason is that there are certain kinds of science, which yield benefits that are general, rather than specific to individual products, and hence generate economic returns which cannot be captured by any single company or entrepreneur. People or organizations that have no commercial interest in the results consequently fund most pure research, and the continuation of this kind of funding is essential for further advance.

BASIC VERSUS APPLIED SCIENCE

In industry the term "research" is frequently used to describe innovation with existing technology, which academic scientists would normally describe as development. This different use of the word "research" can lead to many misunderstandings. In this paper I use the word in the sense understood by academic scientists.

Misunderstandings also arise from the frequent assumption that advocates of the utility of basic science subscribe to the so-called "linear model", according to which basic research is supposed to lead to applied research, which in turn leads to industrial development and then to products. While there are many cases in which this has indeed happened, it is also easy to find examples of advances in

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technology which have led to advances in basic science, such as that given by George Porter (Nobel Laureate in Chemistry) who pointed out that "*Thermodynamics owes more to the steam engine than the steam engine owes to science*".

Unfortunately, such examples have led some people to advocate an anti-linear model. For example, Terence Kealey has recently written a book arguing that economic progress owes nothing to basic science, which should therefore not be supported by governments. He points out correctly that the development of steam power, metallurgic techniques and textile mills, which drove the start of the industrial revolution in England, were based on scientific understanding and mechanical engineering principles dating from before the 17th century, and owed nothing to the 17th century scientific revolution (Newtonian mechanics, calculus, etc.). This is true, but it is certainly not true of many later industrial developments, as I hope the examples that I shall give later will demonstrate.

So the connection of science and technology is neither linear nor anti- linear, but in fact highly non-linear, and it has been claimed that "historical study of successful modern research has repeatedly shown that the interplay between initially unrelated basic knowledge, technology and products is so intense that, far from being separate and distinct, they are all portions of a single, tightly woven fabric". Nevertheless, a broad distinction can be made between science (~ knowledge) and technology (~ means by which knowledge is applied), and between different forms of science. I do not like the terms basic and applied science: after all, who can say in advance what is applicable? However, these terms can be useful provided they are defined in terms of motivation; thus:

Basic science - motivated by curiosity
Applied science - designed to answer specific questions.

The difference between basic, or pure, and applied science was beautifully illustrated by J.J. Thomson - the discoverer of the electron - in a speech delivered in 1916:

"By research in pure science I mean research made without any idea of application to industrial matters but solely with the view of extending our knowledge of the Laws of Nature. I will give just one example of the "utility" of this kind of research, one that has been brought into great prominence by the War - I mean the use of X-rays in surgery...

Now how was this method discovered? It was not the result of a research in applied science starting to find improved methods of locating bullet wounds. This might have led to improved probes, but we cannot imagine it leading to the discovery of the X-rays. No, this method is due to an investigation in pure science, made with the object of discovering what is the nature of Electricity."

Thomson went on to say that applied science leads to improvements in old methods, while pure science leads to new methods, and that "applied science leads to reforms, pure science leads to revolutions; and revolutions, political or scientific, are powerful things if you are on the winning side". The important and very difficult question for those responsible for funding science is how to be on the winning side.

THE POSSIBILITY OF DISCOVERIES OF ENORMOUS ECONOMIC AND PRACTICAL IMPORTANCE

It is not hard to show that expenditure on basic science often leads to discoveries of enormous economic and practical importance, is highly profitable, and has easily paid for itself. Casimir, the renowned theoretical physicist, and one-time Research Director of Philips, has given a splendid list of examples:

"I have heard statements that the role of academic research in innovation is slight. It is about the most blatant piece of nonsense it has been my fortune to stumble upon.

Certainly, one might speculate idly whether transistors might have been discovered by people who had not been trained in and had not contributed to wave mechanics or the quantum theory of solids. It so happened that the inventors of transistors were versed in and contributed to the quantum theory of solids.

One might ask whether basic circuits in computers might have been found by people who wanted to build computers. As it happens, they were discovered in the thirties by physicists dealing with the counting of nuclear particles, because they were interested in nuclear physics.

One might ask whether there would be nuclear power because people wanted new power sources or whether the urge to have new power would have led to the discovery of the nucleus. Perhaps - only it didn't happen that way.

One might ask whether an electronics industry could exist without the previous discovery of electrons by people like Thomson and H.A. Lorentz. Again, it didn't happen that way.

One might even ask whether induction coils in motorcars might have been made by enterprises, which wanted to make motor transport, and whether then they would have stumbled on the laws of induction. But the laws of induction had been found by Faraday many decades before that.

Or whether, in an urge to provide better communication, one might have found electromagnetic waves. They weren't found that way. They were found by Hertz who emphasized the beauty of physics and who based his work on the theoretical considerations of Maxwell. I think there is hardly any example of twentieth century innovation which is not indebted in this way to basic scientific thought."

Casimir's examples have a number of features in common:

- The applications of new knowledge were highly profitable;
- They were totally unforeseen when the underlying discoveries were made;
- There was a long time-lag between the fundamental discoveries and their exploitation;
- The discoverers in general did not get rich.

There have been some attempts to quantify the huge pay-offs from fundamental research. I will mention three:

1. A recent US National Science Foundation study found that 73% of the papers cited in industrial patents were published "public science", overwhelmingly basic research papers, produced by top research university and government laboratories.

2. The well-known economist John Kay has estimated (on the basis of the conservative assumption that without electricity national income today would be at least 5% less than it is) that the benefit to the UK economy of accelerating the development of electricity by Faraday, Maxwell and others, by one year, would have been (in 1985) at least 20 billion pounds, or some 40 billion pounds today.

3. A much cited study by Mansfield in 1991 claimed to show that public investment in basic science generates a return of 28%. Mansfield's figure was derived from a sample of 75 major American firms in seven manufacturing industries (information processing, electrical equipment, chemicals, instruments, pharmaceuticals, metals and oil). He obtained information from company R&D executives concerning the proportion of the firm's new products and processes commercialised in 1975-85 that, according to them, could not have been developed (at least not without substantial delay) in the absence of academic research carried out within fifteen years of the first introduction of the innovation. Mansfield's work clearly demonstrates that there are large returns, but his analysis involves many assumptions and the actual figure should be taken with a large pinch of salt. Indeed, given the very non-linear relation between research and final products, quantitative measurement is clearly impossible.

CONCLUDING REMARKS

In this paper it was argued that:

- Basic science is very important, culturally and economically.
- Governments should support basic science as their first priority, relative to funding of applied

research, and developed countries should not leave it to others.
- Attempts to "direct" research in basic science, on the basis of economic objectives, are generally futile, and could be counter productive.

From 1945 to the 1980s the attitude to funding basic science was generally favorable in most industrial nations. In this period, there was wide acceptance of the arguments put forward in a celebrated report published in 1945 by a group led by Vannevar Bush, the US presidential Science Adviser, entitled "Science - The Endless Frontier". This report argued that money spent on basic research would, sooner or later, contribute to wealth, health and national security, and that one should not worry too much about exactly what form these benefits might take, and when they might occur. This view prevailed through the 1960s and public funding for basic research grew appreciably in real terms year by year. It must, however, be admitted that, in the US at least in the 1950s, there was a tacit understanding that if governments kept university scientists happy by funding their research, then those scientists would be available to help in the case of war, as had happened during the Second World War.

TECHNOLOGIES OF THE 21ST CENTURY AND THE ROLE OF UNIVERSITIES

*Riazuddin**

ABSTRACT

A brief historical survey of technological developments in the last century is given. The factors which drive technological development and the role of science in this development are discussed. New and emerging technologies are pointed out and the role of universities in exploiting them is stressed. Finally, it is pointed out that unconstrained technology may lead to serious social and ethical problems, necessitating creation of ethical codes in science and technology. It is emphasized that, over the years, the science-technology chain has become shorter and shorter, with the result that a scientific discovery becomes utilized more quickly in the shape of technology.

Moreover, our means of information and communication have become increasingly more rapid. Thus, in a human life-time, the world is transformed much more drastically than was the case, say 50 to 60 years ago. As a consequence, jobs will become increasingly more sophisticated and will use new knowledge and an individual would be expected to have more than one career during his life-time. What strategies should universities develop to cope with this challenge? The issues involved are discussed.

TECHNOLOGY IN HISTORICAL PERSPECTIVE

Modern Science is relatively new. Its roots date back to the 17th century. Technology, on the other hand is pre-historic. Our technology has been of two kinds: green and grey. "Civilization began with green technology, with agriculture and animal breeding, ten thousand years ago. Then, beginning about three thousand years ago, grey technology became dominant, with mining, metallurgy and machinery. For the last five hundred years, grey technology has been racing ahead and has given birth to the modern world of cities, factories and supermarkets"[1].

The grey technology has gone through three important phases. The first phase, which took place at the end of 18th century, was mainly created by "handy men" as C.P. Snow calls them. Academic science played very little role in this phase. In the second phase, chemistry played a major role: giant chemical companies were established in Europe and U.S.A. In the third phase, atomic particles like electrons, nuclei, and atoms played an essential role; here the development of physics in the 20th century in universities played a crucial role. There are two remarkable things about the third phase, which resulted in the first place from two conceptual revolutions, relativity and quantum mechanics, which took place in the 20th century: Firstly, investigations that seemed totally irrelevant to any practical objective or practical problem yielded all the modern scientific and technological developments. "Nuclear energy, lasers, x-ray technology, NMR imaging, semiconductors, computer, internet, superconductors only exist because we have relativity and quantum mechanics. To our society and to our understanding of nature, these are all-encompassing"[2]. The second remarkable thing about this third phase of the technological revolution is that it has reversed the old saying "Necessity is the mother of invention": "Invention is now apparently the mother of our necessities. Inventions only later become necessities! Time and again, inventors created things that had to wait many years to be recognised for their practical value. Nobody really needed the aeroplane, the FM radio, television, xerography, lasers, transistor, or the quantum mechanics that led to the transistor"[3].

Thus we have what came to be known as the science - technology chain, which is largely responsible for the great scientific and technological progress of the 20th century. Technology today uses science with a time-delay of order of 10 years; science, in turn, is driven by the new developments in technology; and both progress together. The science - technology chain is becoming shorter and shorter, so that, on one hand, the distinction between basic and applied science is disappearing and, on the other hand, the pace of introduction for new technologies is accelerating [see Figure 1 & 2].

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EMERGING GREY TECHNOLOGIES

Having brought out the role of academic research in modern technology and the interdependence of science and technology, let me now enumerate some emerging grey technologies that are likely to dominate the 21st century:

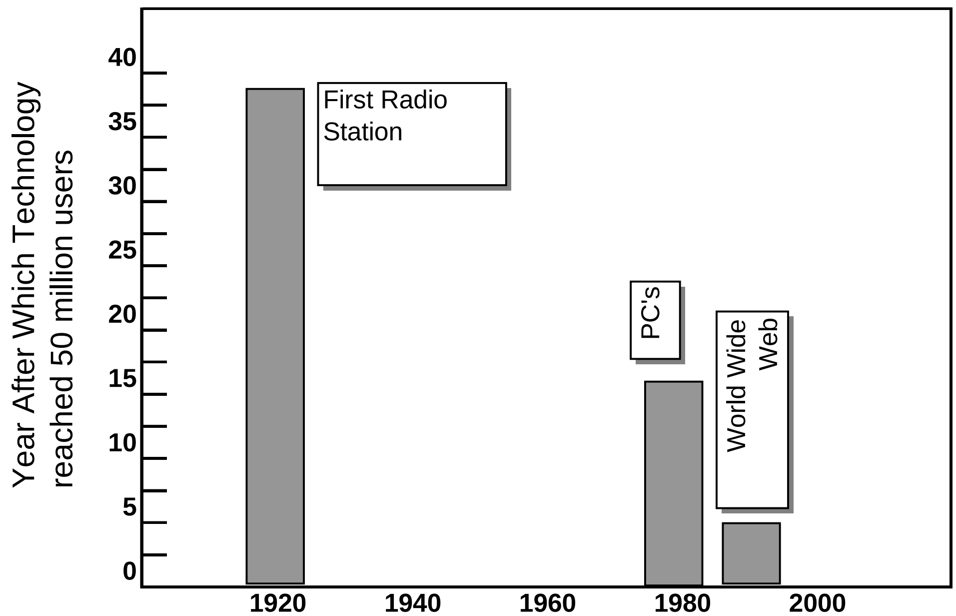

Figure - 1.

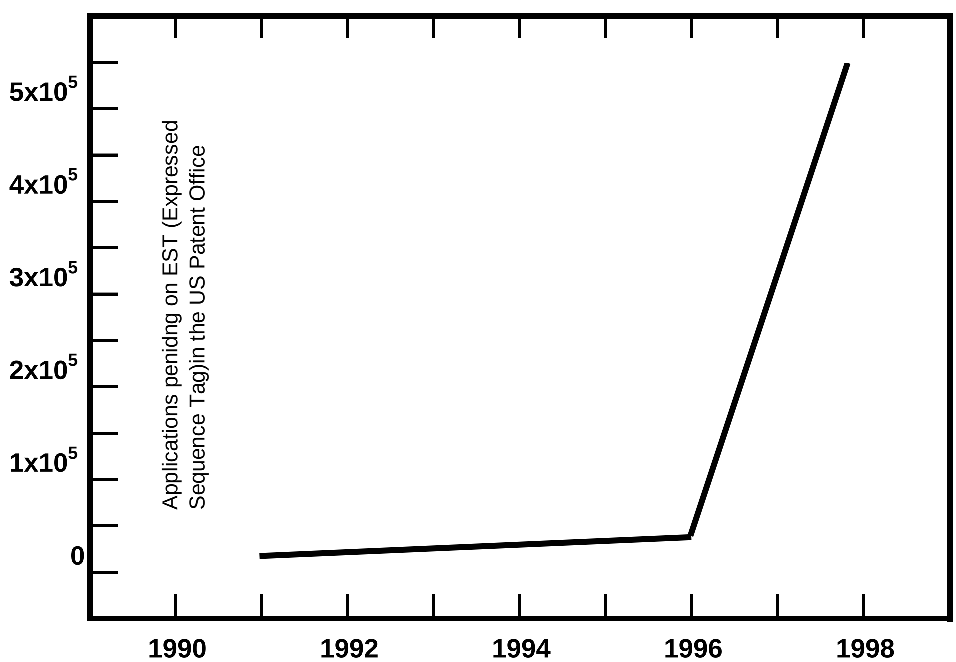

Figure - 2.

1. **New Materials**: High-technology products often depend on "special materials": alloys, composites, doped silicons; ceramics, magnetic materials and polymers. These are special, because of the processing they require and not because the raw material, out of which they are made, is scarce or unevenly distributed.

2. **Nano-technology:** In late 1959, Richard Feynman in a lecture" There is Plenty of Room at the Bottom" proposed that machine-tools could make smaller machine-tools, and that these in turn could make even smaller machine tools, and so on, until the tools were molecular in scale. Such tools, Feynman suggested, might fabricate vast numbers of ultra-small, ultra-fast computers, various micro- and nano-scale robots, and even medical machines that could act as miniature surgeons. Nano-technology may be defined as "the construction and utilization of functional structures and materials, with at least one characteristic dimension at the nanometre scale"[4]. There is a tremendous potential of nano-scale science and technology across a broad spectrum of basic and applied research. "Nano-technology is, to inanimate matter, what biotechnology is to animate matter". It is the logical consequence and ultimate destination of our quest for the control and manipulation of matter[5]". Both the interest of major US institutions and commercial enthusiasm are indicated by the charts shown in Figure 3 & 4.

   In sum, this is a technology with momentum. It will go forward - for good or ill. For those who might think that it is a game for advanced countries, let me remind them of the following words of Dr. Homi Bhabha, who argued, one year prior to Hiroshima: "An Institute is needed as an embryo, from which I hope to build in the course of time a school of physics comparable to the best in the world. When nuclear energy has been successfully applied to power production, in say a couple of decades from now, India will not have to look abroad for its experts but will find them ready at hand".

   Countries like Pakistan missed the transister revolution, it is now trying to enter I.T. when the I.T. bubble has already burst. Let us, therefore, realize the position, so that when the nano-technology revolution would be on us by 2010 ~ 2020, we are ready for it.

3. **Information Technology:** Higher densities of information, on scaled-down computers, will become a necessity in the near future. As an example, let us consider the computing challenge to be faced in the analysis of data from Compact Muon Silicon Detector (CMS) associated with the Large Hadron Collider (LHC), which will be the world's largest particle-accelerator being developed at CERN, the European Organization for Nuclear Research in Geneva. The data-rate would be 100 MB/sec so that the amount of data to be analysed per year by two thousand users, distributed geographically in various parts of world, will be 1 PB (10^{15}B). To put it in proper perspective, the bench mark for PC (1999) is 15 Spec Int 95 and what would be needed is 25,000 Spec Int 95.

4. **Space Technology:** The exploration of the solar system and the physical environment of the earth, so as to reduce the negative effects of technical change on the environment, in terms of pollution, desertification, environmental degradation, waste management, etc.

EMERGING GREEN TECHNOLOGIES

1. **Biotechnology and Genetic Engineering:** During the last fifty years, we have achieved a fundamental understanding of the processes occurring in living cells. Molecular understanding of the gene-basis of living organisms could lead to new processes and products for agriculture, industry, the environment, and for animal and human health. If used wisely, "one of its major benefits will be to allow us to make great areas of the globe economically productive, without destroying their natural ecology[6]".

2. **Nano-medicine:** "The science of diagnosing, treating and preventing disease, with the use of novel molecular technologies — from "smart drugs" that target specific organs or cells, to miniature robots that can ferry materials into and out of cells, and even enter cell-nuclei to repair damaged genes[7]".

ETHICS

Increase of science and technology by itself is not enough to guarantee genuine progress; they alone

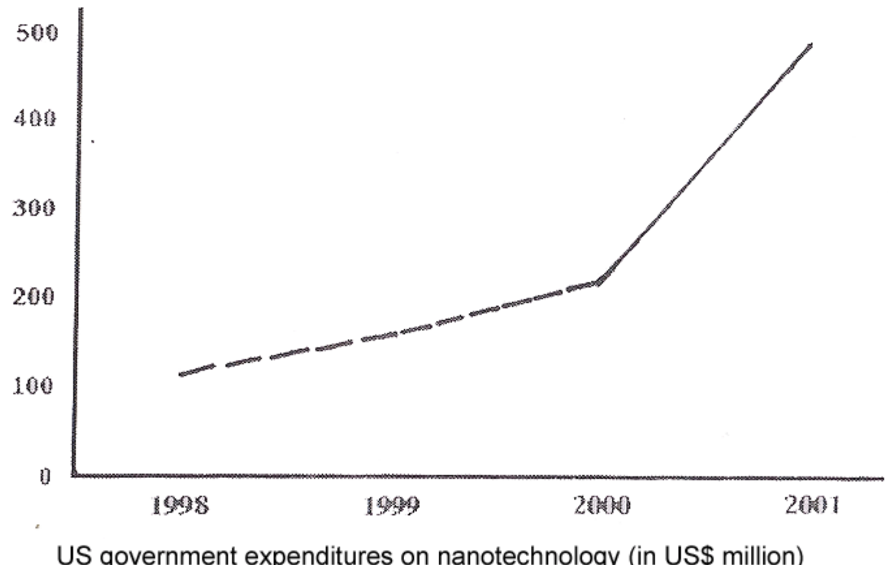

Figure - 3: U.S. Government Expenditures on Nano-Technology (in US$ million)

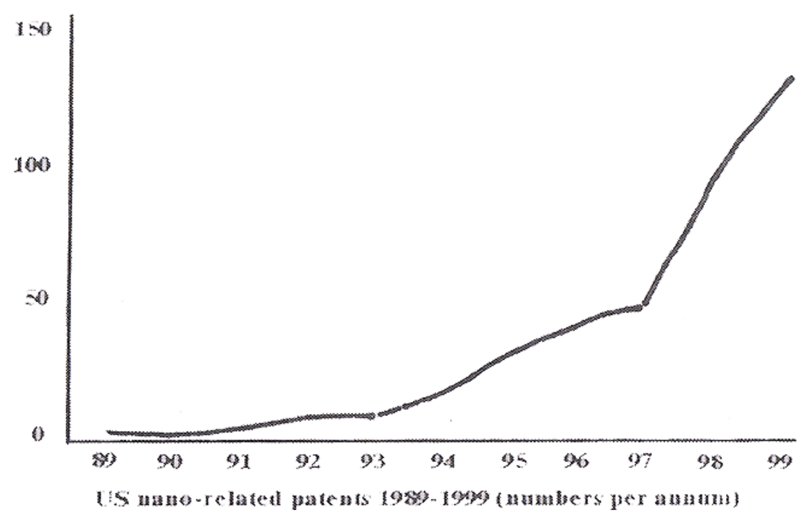

Figure - 4: U.S. Nano-related Patents 1989 – 1999 (number per annum)

cannot bring social justice to human societies. There is an ugly side of technology. The 20th century saw the best, as well as the worst of science and technology. A new nation was born in the last century - a nation that dwells in total silence; a nation that cannot speak. Scottish writer Gil Elliot calls it a nation of dead. He estimates its population to be 110 million, a fully cosmopolitan nation[8]. It was created by man-made weapons. Grey technology brought us nuclear weapons, as well as internet. Similarly, the green technology brought us anthrax bombs as well as antibiotics. Besides the dangers of man-made weapons, technology brings other dangers having nothing to do with weapons. One is the mismatch between the new waves of technology and the basic needs of the poor. The point is that the market-driven technology usually results in the "toys" for the rich, since they are expected to pay more than the poor for new products, thereby resulting in the ever increasing gap in economic well-being between rich and poor. The increasing gap between human needs and technology can only be filled by ethics.

Another problem of ethics, more serious than the handling of weapons of mass destruction, which humanity is going to face is from the convergence of genetic engineering, nano-technology and computer technology. "The ultimate danger comes from technology's power to change the nature of human beings by the application of genetic engineering to human embryos. If we allow a free market in human genes, wealthy parents will be able to buy what they consider superior genes for their babies. This could cause a splitting of humanity into hereditary castes. Within a few generations, the children of rich and poor could become separate species. Humanity would then have regressed all the way back to a society of masters and slaves. The free market must not extend to human genes[1]". Only through proper ethics can we assert control. But ethics, like science, has to be general. Here "scientists and religious believers, physicians and lawyers must come together with mutual respect, to achieve a consensus and to decide where the line should be drawn[1]". We cannot constrain technology - it will go forward, but perhaps we can constrain ourselves.

ROLE OF UNIVERSITIES

The basic issues which a university has to address are:

- Derivative science and technologies involving many disciplines are becoming important.
- Green technology will be moving ahead, faster than grey technology, and will dominate over the latter.
- Over the years, the science - technology chain has become shorter and shorter, with the result that a scientific discovery becomes faster utilized in to technology. Moreover, our means of information and transportation have become increasingly more rapid. Thus, in a human life-time, the world is transformed much more drastically than it was the case, say fifty to sixty years ago. As a consequence, the jobs will become increasingly more sophisticated and will use new knowledge, and so an individual would be expected to have more than one career during his lifetime. This requires that education must be increasingly broad, aiming at developing potential for further and continuous learning, rather than rote learning and premature specialization. To be sure, it does not mean that "vocational" training and professional education are not needed. These are needed for the current job-market, but such people can be trained in existing institutions, and universities which specialize in Engineering, Business Administration, Commerce, Agriculture and Medical Education. But this, now outdated concept, must not continue for new universities. A university has to be a flexible institution so that, within one institution, one has the full range of knowledge; from science to engineering to management and economics, even to public policy, law and social analysis. A modern university must have faculties of humanities (which include social sciences), basic sciences, engineering, agriculture and medical, at one campus, so as to provide an integrated form of education. Existing general universities must re-orient themselves, with added new faculties, where needed, to future trends in education, outlined above, and prepare people and society for a lifetime of learning, with balanced curricula in a multidisciplinary environment.

The following goals and actions are needed on the part of a University:

- Provide a dynamic programme, aiming to develop a potential for a lifetime learning, since in the conditions of modern life of rapid change, an individual can be expected to have more than one career during his/her lifetime.
- Develop total competence in people that require balanced curricula.
- Make use of new information and communication-technologies, which will facilitate access to higher education for groups that would otherwise lack such opportunities, this would provide for the advancement and continuous development of work force.
- Adopt quality-concepts in education, so as to attract and retain a high-calibre faculty, build research groups around a creative faculty, ensure greater mobility of faculty, through international contacts, and attract talented and gifted students.
- Strive for a linkage with government and industry, thereby seeking and acquiring funding for contractual research from external sources.
- Strive for international collaboration with big centres of research, like CERN in Geneva, which is a fine example, in which high technology and pure science reinforce each other and which is open to

every body.

- Of course, a University cannot flourish without basic research, which is needed to expand the frontiers of our knowledge, to further our social, economic and scientific insights, to build new technological applications of our scientific insights, and above all, to produce new generations of researchers. Basic research needs patronage and financial support. For advanced countries, this support finds many channels: governments, industry and endowments created by philanthropists. In the state of Texas alone, there are 42 endowed chairs and 72 endowed fellowships. Creation of endowments for education and research has not yet entered our culture. But this culture has to come if we have to make progress.
- Finally the universities within the country must go through globalisation among themselves, establishing microwave links among themselves, in order to reduce the science and technology gap among ourselves. This is all the more necessary, since we may face in our universities a serious problem of critical size of research groups. Thus, to begin with, it may be more feasible to distribute Centres of Excellence, one or two in each of the new technological and scientific disciplines mentioned above, among the various universities in the country or even in the region.

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SCIENCE & TECHNOLOGY FOR SUSTAINABLE DEVELOPMENT: QUALITY OF RESEARCH IN R&D INSTITUTIONS

*N.M. Butt**

ABSTRACT

Science and Technology in a country is an essential requirement for a strong economy and security needs of any country. The countries having strong and meritable S&T institutions are indeed the "Advanced Countries" in the world and their people enjoy a high standard of living. Further it is also very important that to continue such an advancement the sustainability of the S&T institutions is insured by effective planning by the governments in power.

The important parameters required such as regular availability of a well-planned meritable human resource, the application of the research quality parameters for S&T, human resources and the institutions are discussed with respect to the available examples of advanced countries. Emphasis has been laid on developing strong research and development culture and the methods of ensuring quality of research are discussed. Extensive literature is referred to for further reading on this important subject for the interested readers. Examples of progressive and advanced countries of Europe, USA and Japan are discussed, describing the mechanism by which the quality research and development for their S&T institutions has been emphasised to ensure their sustainability as well as effective utilisation of quality R&D for Industrial products to help the economy effectively.

It has been proposed that for the sustainability of S&T institutions, a visionary planning is important to prepare qualified and competent manpower to regularly replace the retiring manpower. Extensions beyond retiring age are in injustice to good successors and are damaging to the sustainability of S&T institutions. Examples of Sustainable institutions in Pakistan and abroad have been mentioned.

Scheme for ensuring better utilization of basic research to improve Industrial products have been proposed which could help the economy of a country. Examples of such recent schemes benefiting the economy of the advanced countries such as Germany and Japan are given.

INTRODUCTION

Sustainable development for any country is most desirable for any country for its progressive existence and a decent life for its people. There are a number of essential parameters which play an important role for such a sustainability of a country. Apart from good governance and social excellence, the scholars and men of science and technology in a society play a pivotal role. I shall here restrict my discussion to the role played by science and technology in this venture and then in particular the culture of research and development with a measure of "Merit" and **"**High Quality**"**. The countries where science and technology have been well cared for consistently over a period of time, are the most powerful and economically well-advanced. Their subjects are living a very comfortable life with high standards of living and better quality of life. Those countries where S&T are lagging behind have not been developed, are indeed living a poor life and are regarded as the "Under- Developed" countries. Those where efforts are in progress to pay attention to strengthening the science and technology are termed the "Developing Countries".

Although the nations such as oil-producing countries where natural resources are abundant, the people have higher standard of living but they are heavily dependent on the import of consumer goods and high technology utilities from the technically advanced countries. Their raw materials and natural resources are exported without value-addition and thus the imported high-technology items consume their natural resources with a lot of exploitation.

Apart from natural resources of a country, the most important resource is "human resource". Even if the natural resources are scarce but the human resources are well- developed in the field of science and technology, the countries are well advanced and their people enjoy a high standard of living. The obvious

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examples in South Asia are Japan, Singapore, Korea, Malaysia, Taiwan and Thailand.

TWO MODELS OF SUSTAINABLE DEVELOPMENT

We can consider two main models for a sustainable development, in both of these however, science and technology play the controlling role.

In Model-I the stress is laid to improve the economic conditions in the country through the mass production of low-technology consumer goods, thus gradually improving job opportunities and earning power, thus raising the standard of living of the common man. In Model-II the emphasis is on higher education and development of higher science and technology and its use as a vehicle of high value addition to local products as is done in USA, Japan and in most West European countries. The Model-I is the case of newly emerging progressive nations like Malaysia, Thailand, Korea, etc. However at some stage the effluence of higher education and higher science and technology in accordance with Model-II is essential if the country has to "sustain" its progressive existence. With reference to education, it is important to note that exclusive stress on mass literacy of lower education is not optimally useful, but it is the necessary level of higher education supported by a strong culture of quality research and development which is essential for proper high-tech developments. This means that the education with the proliferation of the primary education only does not make a country developed. For instance, in Sri Lanka there is a very high percentage of lower education (about 86%) but the country is not developed in the sense that similar smaller countries (having dominant higher education) like Switzerland in Europe have much higher standard of living than Sri Lanka. The obvious reason is the domination of higher education backed by a strong research and development of high technology which adds to better economic development of Switzerland.

In my opinion the Model - I has a shaky sustainability for economic stability as well as progressive strength of a country. The Model - II backed by high quality scientific research and development has a long term progressive stability as has been established in the history of advanced countries like USA, UK, Europe, Japan, China, etc. A better approach of course, is the well planned overlap of the two models, keeping in view the economy of the country.

At the same time there is obvious evidence that an advanced country faces severe decline if it neglects higher education and science and technology. A very recent example of this decline is the case of the USSR. When, in earlier times, scientific research was well-supported by the government during the tenure of Stalin and Khrushchev, USSR developed into a powerful country. Due to initiation by Khrushchev, within 10 years a Science City, *Akademgorodok* about 30 km from the city of Novosibrisk, flourished with science eminence in research at the international level and even US thought of the fact at the time that the USSR got a lead in space science when Sputnik was launched into space in 1957. Thus the USSR made rapid strides to be a strong country of world influence. The development of science of the 60's thus led to the Nobel Prize winning work in the field of semiconductors and opto-electronics (Prof. Zhores Alferov was awarded the Noble Prize in Physics in year 2000 for this work of the 60's.). But with the fall of Khrushchev, the support to science and technology waned and the fall of Russian science and technology started and as soon as in the recent years (after the dismemberment of the Soviet Union) this support was further neglected, the country plunged into economic problems and went into oblivion of the world notice[1]. Since 1991 government funding of scientific research shrunk six-fold in Russia and as a result, Russia fell by 1999 from its lofty pedestal as a cold-war superpower to the bottom rung of the states with least scientific potential. The Science City of Akademgorodok presents pathetic situation of science funding. The salaries of Russian scientists have been reduced (a promising computer scientist earning 90 dollars a month, drastically lower than in advanced countries) and they are in a very frustrated situation. The research quality and quantity have both gone down in the past 10 years. Such is the importance of the support of "political will" and the funding of science if the countries have to have sustainability of development. This recent example of dependence of sustainability of a country on the Research and Development in science and engineering is an eye-opener for the developing countries as well as for the developed countries. Aware of this fact the advanced countries however continue keeping priority of higher education and science and technology in their annual budgets and they remain in the fore-front of the scientific research and the consequent economic development[2]. It is interesting to quote a paragraph from the recent biennial report of the National Science Board, USA for the year 2000 submitted to the US President where it is stated; that *the research and development in the United States is on the rise and is providing a boon to the economy. The two-volume edition of Science and Engineering Indicators 2000 documents that the U.S. economy approached the end of the 20th century with "unprecedented real growth, miniscule inflation, low unemployment and strong consumer and investor confidence." An indicator of that confidence was seen in the continued rising investments in research and development, which in 1998, grew by 6.5 percent, adjusting for inflation. Meanwhile, the U.S. Gross Domestic Product grew by almost four percent per year for the two-year period 1997-98, bettering historical averages. Federal support for research and development rose by 2.1 percent inflation-adjusted, in 1998. The much larger percentage increase in industrial research and development, however, helped to lower the federal share of the national total to below 30 percent for the first time since 1953, when the National Science Foundation started monitoring these trends.* The Chairman of this board further states "that the over all economic impact of a "stimulated" research and development climate has been positive. There has continued to be a consistent balance between investments in fundamental and applied research and development within the US and steady increases in these investments since 1980 that have contributed to a strong research system and a vital economy."

SOME MAIN ASPECTS OF SUSTAINABILITY WITH REFERENCE TO S&T

There are a number of aspects for which sustainable development is being discussed today. They both require social as well as technical aspects to deal with. The social aspects to deal with are;

1. Poverty Alleviation
2. Environmental Issues
3. Good Governance and Management of Society
4. System of Government
5. Human Resources
6. Traditional Culture & Religion
7. Social Implications of Technical Advancement
8. Provision of Clean Water, Air and Shelter for the People.

The Technical aspects to deal with are:

1. Political will for Higher Education and Science and Technology
2. Vision for establishing strong and meritable R&D Institutions
3. Emphasis on Quality rather than Quantity in Technological Research and Development Institutions.
4. Continuous Development or Replacement capability for retiring individuals rather than service extensions i.e. a well planned and a viable infrastructure.
5. Continuous Monitoring of Scientific and Technical progress
6. Up-date of Information Technologies and their use for economic development as "technology-support" applications.

Although all of these factors play their respective role in the sustainable development of a country, I shall like to discuss the contributions of the "Quality Research and Development" to this aspect. This is one of the primary factors for the technical part of the sustainable development and has a strong correlation with the economic indicators like GNP as a mark of standard of living.

One of the dominant and most used indicators of quality of research and development is "Citations Per Paper" (c.p.p) for scientific research and the "Applications for Scientific Research". A recent data (year 1999) of 79 countries shows [Fig.1,2] clearly that both these parameters are large for well developed and rich countries, say in the group of the top 30 nations [mostly consisting of European nations, USA and Japan][3]. The same is the case of the world-ranking of the countries for research quality defined by the "citations per paper", c.p.p. [Fig.2]

JOURNAL IMPACT FACTOR (JIF) *VERSUS* QUALITY OF RESEARCH

A brief discussion of the Journal Impact Factor as a measure of Quality of Research publications is useful for scientific purpose to clarify certain prevalent misconceptions in its use for assessment of research merit of scientists and scientific Institutions.

The Journal Impact Factor (JIF) was introduced in 1955 by Prof. Eugene Garfield of, USA to assist scientists in the area of Information Science. Since a large number of research journals were published in any one branch of science like Physics, Chemistry, Biology, Agriculture, etc. and the cost of Journals was increasing day by day it was a problem for the research institutions for their libraries to select journals of optimum utility within the allocated budget constraints. Mainly to help in this matter, Prof. Garfield introduced the '*Journal Impact Factor*', as a quantitative measure to assess the comparative utility of the research journals. JIF was measured from the number of '*Citations*' made to the papers by other researchers published in a Journal over a period of 2 years following the publication of the journal[4, 5]

Thus JIF is equal to the number of total citations to papers in the journal, 2 years after its publication *divided by* the number of total papers published in the journal.

$$JIF = \frac{Cy+2}{Ny}$$

Where "y" is the year in which the journal was published and Cy+2 is the sum of citations (of those papers of the journal) in the two years after the publication of the journal. Two years is considered a reasonable time during which the papers published in a journal could come to the notice of other researchers. Although some authors have increased the two-year period based on their later research in this regard.

Although the numerical value of JIF was mainly for a '*possible*' assistance for purchasing the appropriate journals but in early times attempt was made to use this parameter as a measure of higher quality of research of the papers which authors or scientists published in journals of higher JIF[6, 7]. This was immediately negated and severely criticized by a majority of researchers and a large number of detailed research papers were published which proved on statistical analysis that it was incorrect to judge that the quality of a researcher should simply be judged by the Impact Factor of the Journal in which he published the paper[8, 9, 10, 11, 12, 13, 14].

It was, however, clearly established that the quality of research publication be judged by the '*Average Citations to the All Papers*' i.e. citations per paper of the author rather than JIF which represents the average citations to papers of all authors who publish in that journal and assigning this average to one author is not logical. One author must not share the credit of "citations of papers of other authors" who have published in that one journal. Rather any author must get the credit of '*the citations to his own paper alone*', which is given by another parameter independent of JIF and is referred to as "citation Impact" or "citations per paper, c.p.p," and rightly pertains to the quality of papers of that "particular author alone".

Therefore, citations per paper (c.p.p) is now normally used as a measure of research quality for a scientist rather than JIF. For further reading on this topic one could refer to references 15, 16, 17, 18, 19, 20, 21, 22. While c.p.p is a good measure of quality of Research papers, for a detailed assessment of a group of scientists a Peer Review Committee should decide their relative merits where of course quality of research should be a dominant factor among other considerations. Thus for sustainability of science and technology in a country, the assessment methods of quality of research in this area are extremely important. The extensive references given here will be very useful in this regard.

However, it is important to note that the support to the assertion that those nations, who apply the political-will and cater for investment in research and development in S&T, have higher standard of living. This is well illustrated by a recent study on this aspect. [Fig.3 (a) and (b)]

Even in quantitative productions of research, defined by the '*number of papers per person*' as shown by the study of OECD [Fig.1], it is clear that the same group of countries are on top ranks, only their '*ranking*' may be different on the research quality assessment scale of c.p.p [Fig.2].

REFERENCE ON JAPAN

Studies on Japan indicate that Japan has over the years invested relatively more in basic science research than in application of technology. This was based on the realization that strong development in research leads to better innovation for application of science to industry which means both quality and quantity in production. The number of researchers in Japan has increased over the years, both in the universities; research institutes as well as in companies. [Fig.4].

Moreover, the trends in budget for Grants-in-Aid for scientific research have been progressively increasing and it increased by 2.5 times over 10 years, from 45 billion Yen in 1988 to 112.2 billion in 1997 [Fig.5].

Over a period of 20 years from 1975 to 1996 [Fig.4], the researchers in universities increased from 134,458 to 242,262 about 1.6 times while such an increase for companies has been from 146,604 to 384100 about 2.62 times in the same period. This shows a trend of significant increase in the research and development for science and technology.

Also the trends in research funding have gradually increasing percentage amounting to 20% for universities and 65.2% for companies over a period from 1986 to 1995. [Fig.6]. However, the important thing to note is that while the universities are spending relatively more on basic research [about 53% of the allocated budget] the companies spend correspondingly 6.6% on basic research and 71.3% on the development, the requirement of the companies being more on production oriented R&D. These relative expenditures are given in [Fig .7].

The boost to research and development efforts in the country and the support to post-doctoral research were given special attention in a special programme to support about 10,000 post-doctoral fellowships. From 1985 to 1998 this increased from 176 to 5,701, an increase of over 30 times [Fig. 8].

These research supporting measures improved the world ranking of Japan in quality of research as indicated by '*citations of research*' published and placed Japan among the first 5 nations in most of the scientific disciplines and at ranking No.2 in Agricultural and Material Sciences [Fig.9]. This relative shift towards basic sciences will not only further boost the product quality of Japanese goods and thus strengthen the economic sustainability but it will also add to the knowledge-based eminence among the advanced countries of the world. Already the Nobel Prize for chemistry for the year 2000 was shared by a Japanese Chemist, in the area of conducting polymers. Japan is thus poised to be a strong country in the world both economically and research wise.

In attaining this improvement in research development, Japan exercised a systematic approach to the monitoring techniques for efficient production in research. The system of '*self-evaluation*' evolved with specific rules of self monitoring in the universities is being followed in most of the universities (about 70%) [Fig.10] and this self-regulation in science is a matter of great self-discipline.

U.S FUNDING FOR RESEARCH

In the U.S, although a leading country in science and technology, the funding for research and development has changed its pattern. The federal share for R&D has been decreasing over the period of last 10 years. However, while the federal share for R&D has decreased, this has been compensated by the corresponding increase in the '*Industry Share*' in the R&D at the National level, sustaining "the country's research on the world scene as a leading country in the world. This mutual adjustment of funding on R&D between Federal budget support and the Industry contribution is well represented in [Fig.11]. Thus the country's economic development is sustained over longer periods although economic regression does take place because of the management policies and the unforeseen happenings like the terrorists attack on WTC in New York and on Pentagon in Washington on 11th September, 2001. However the stronger science and technology infrastructure of the United State lends a strong support for recovery of the economy in shorter periods of time. Therefore, a strong S&T base is again a great help to US in periods of economic difficulties to sustain country's eminence. Strong R&D base in science and technology quickens the economic recovery when management measures are improved to meet the requirements of new steps for economic recovery. If, on the other hand, a setback occurs in the economy of countries with a weak base of R&D in high science and technology, such as for poor countries, the economic recovery becomes an unachievable target and things may go from bad to worse.

In the recent good days of US economy, the investments in research grew in 1998 by 6.5 percent. And in the two years period of 1997-98, the US GDP grew by almost 4 percent, bettering the historical averages. Federal support for R&D rose by 2.1 percent, inflations adjusted[2].

Further, much larger percentage increase in industrial research and development as referred to earlier, however, helped to lower the federal share of national total to below 30% lowest since a period of nearly 50 years.

Another advantage for strengthening the sustainability of R&D in science, the US adopted the strategy of making use of global science and the US companies entered countries to the tune of about 5100 over a period of about 10 years after 1990. The US companies invested about three times more in foreign cooperative research and development than the domestic similar expenditure. This resulted in an increase of 20% in co-authored research publications with foreign collaborators than compared to just 12% a decade earlier[2].

Another useful trend for the sustainability of US R&D institutions was the change in approach of the universities to concentrate more on patenting their research. The patents increased from about 250 per year in 1970 to about 3100 in the year 1998.

While this shift in approach of the universities towards patented R&D is noticeable today there is also a desire of US to lead the world in scientific research of large size or mega science research projects (MSRP). Eight such mega projects such as observation network for crustal movement in China, or H.7 – 7U super-conducting Tokamak Fusion experimental equipment or 3rd generation synchronous radiation light source etc. Such projects need large scale investment and contribute to the strength of not only large basic research but also helps the evolution of applied research. But more than that, these projects will prove for the US a source of great national strength in science and technology.

Salient Points

Maintaining U.S. excellence in science is not an impossible dream. Like getting rid of crime or narcotics, it does not require building some vast new infrastructure; most of what we have is fine. The gap between excellence and mediocrity is measured in the low billions of dollars per year. Clearly, continued excellence in science is well within the nation’s reach. Living within tighter budgets will mean following these guidelines[23]:

- *Target federal funds more effectively:* Cutting the least productive federal programs is an obvious way to live within tighter budgets, but the existing decentralized process of science budgeting is ill suited to doing that.
- *Nurture—but do not directly subsidize – industrial R&D:* Industrial R&D needs the fundamental science produced by universities, but companies are clearly quite able to fund the “appropriable” applied research specific to their individual requirements. Let’s not waste federal money on research projects that industry would fund anyway.
- *Rationalize the role of the federal laboratories:* The federal laboratories are valuable national resources that need a clear mission to achieve their potential.
- *Recognize the growth of science worldwide and develop policies to take advantage of it:* This involves issues of international cooperation in research, international movement of scientists, and picking up on scientific advances, wherever they occur worldwide.
- *Protect the federal support for academic research:* Academic research, heavily dependent on federal support, contributes crucially to the overall advance of science and is unlikely to be replaced by private initiatives if federal support is withdrawn.

OTHER USEFUL PARAMETERS FOR SUSTAINABILITY OF S&T FOR ECONOMIC DEVELOPMENT

It has been already discussed that a strong R&D in science and technology is the core parameter for sustainable development of a country. However, some of the other factors are listed below:

1. Role of merit, scientific ethics and self regulation in research institutions are important aspects to practice if these institutions are to be established for long term sustainability.

2. The scientific merit needs to be strictly practised in promotions and for appreciation of meritable scientists. Personal preferences of non-professional nature need to be consciously put aside to keep the national and organisational interest supreme with regard to professional ethics. The exploitation of official position should not be made by taking credit of research work in which one has not contributed any justifiable work. This is particularly so if co-authorship is involved in a research publication. The work done by others should not be shared as a co-author simply because a person may be the Director or the Head of an organisation. In several countries, the regulations are framed under what conditions one could be a co-author[24]. The rules are defined.

3. The ethics of professionalism on international norms do not allow the co-authorship simply because if one is a director or head of the organisation, manages to provide facilities for research of his younger scientists. There are commissions, which act as courts for scientific justice to the violations of scientific ethics pointed out by any affected scientist who can approach such a commission. For example, any younger author, who may feel that his Director or the Group Leader has included his name without contributing properly to the research paper published, can put up his case to such courts to get justice. Such commissions are *Government Sponsored* in Germany and Denmark and therefore the misconduct in science is well looked after[24, 25].

SUSTAINABILITY AND NEED OF CONTINUITY OF MANPOWER PROVISION

The sustainability of R&D institutions greatly depends on the continuous supply of well trained and well qualified scientists at well thought timings to replace the scientists reaching the retirement age. This requires a good vision to see in future the needs of manpower requirements of the organisation, and manage the matters in such a manner that competent and well qualified persons are already available to replace the retiring persons. The extension in services of those who have reached the retiring age is not a proper solution of sustainability of the R&D institutions. In the first instance, it is a human injustice if the retiring person arranges extension in his service, and secondly, it is a weakness of his management of the past years not to train and induct persons to replace the retiring person, particularly when competent persons are available for replacement.

Therefore, the planned and well prepared availability of human resource to replace the retiring persons is an important aspect of sustainability of R&D institutions and is in supreme national interest. A good example of this aspect in advanced countries like U.K and Germany is that all persons retire at the specified retiring age and no extensions in service are given by the government even if the Scientist is a Noble Laureate. However, utilization of expertise of retiring persons is made effectively for national benefits in a variety of other useful schemes made available. Therefore, the Institutions like Oxford and Cambridge universities in U.K or Max Planck Institutes in Germany sustain their meritable existence over hundreds of years. In USA, although there is no specific age of retirement of scientists, but younger competent people dominate the progressive scientific organisations and universities necessary for their sustainability.

In Pakistan, we have well known research Institutions of merit like for example PINSTECH (The premier R&D institute of Pakistan Atomic Energy Commission, in the area of Nuclear and Physical Sciences), KRL (in Uranium enrichment and metallurgical sciences), and HEJ (for chemical sciences). Since these centres of excellence are new in age, their sustainability for future, keeping the level of eminence they have attained, will depend on the availability and consequent replacement of retiring persons by competent people in the years to come. A careful attention of the Government is required to this aspect to ensure the needs of sustainability of these Institutions.

The vision of Dr. Usmani and Prof. Salam gave good sustainability to the working of Pakistan Atomic Energy Commission for about 40 years which has played a leading role in the nuclear capability of Pakistan. Future continuity of its meritable sustainability will depend on, in what manner the aspects discussed above have been taken care of.

The vision of the establishments of KRL by Dr. A.Q. Khan led the country to the development of the Uranium enrichment Laboratories which made very vital contributions in the provision of enriched Uranium to the Nuclear weapon Project of Pakistan, completed under the auspices of the Pakistan Atomic Energy Commission. In addition, KRL has established metallurgical and space technology Laboratories of great importance in the area of high technology.

Similarly HEJ, the Hussain Ebrahim Jamal Institute in Chemistry established at Karachi University with the vision of famous chemist Prof. Salimuzzaman Siddiqui and led successfully with further expansion by Prof. Dr. Atta-ur-Rahman, an eminent chemist, has produced a large number of Ph.D. scientists and this is a good vision for sustainability of the HEJ Institute as a centre of excellence in Chemistry for years to come.

The recent establishment of National Engineering and Science Commission (NESCOM), by the government of Pakistan, under the chairmanship of the eminent Nuclear Scientist, Dr. Samar Mubarakmand (who led the team which successfully exploded the Pakistan's atomic bombs in May 1998) is a promising step for the development of essential scientific and engineering strategic needs of Pakistan. The able and progressive guidance of Dr. Samar Mubarakmand will give a viable strength to our country.

In the field of country's defense, the Institution of Pakistan Army has been sustainable by a praiseworthy vision by the establishment of the Kakul Academy, where regular production of meritable trained young persons are source of continuing strength to our Defense needs in the form of a *Sound Army*. When the experienced generals reach the age of retirement, the competent younger successors are available to replace them. Pakistan Army is thus a successful example of a sustainable Institution in Defense of Pakistan.

Such sort of system may be good to establish for having sustainable Educational and Science and Technology institutions in Pakistan. The Model of Pakistan Army is a good example for this purpose.

NEW MECHANISM OF APPLICATION OF RESEARCH TO INDUSTRY

(Example: Steinbeis Foundation, Germany)

There has always been an urge of applying the outcome of scientific research for improving products of Industry. Several systems have been followed to coordinate the research output (which is mainly done at the universities and research Institutes) to the Industry requirements. Universities, particularly in recent years, have specific liaison officers who interact with industries, and professors at the universities themselves have also direct contacts with Industries to find their problems and solve them through research. On the other hand industry has specific research departments to interact with Professors at the universities. In this way considerable research has been sponsored by the Industries and in return these Industries have derived benefits for their products utilizing the research done at the universities.

Recently certain government helped foundations or commissions have worked purely as technical knowledge-based organisations which have played the coordinating role as '*bridges*' between research institutes and the industries. Such foundations have very competent research based scientists and engineers, usually, who themselves in the past have been research scientists or research engineers. The foundation identifies the problems of Industry and hands it over to the university or to the Institute where in their judgement the problem could be solved. Such schemes in recent years have proved very useful, particularly in Germany and Japan.

In Germany the Steinbeis Foundation, Stuttgart, established about 10 years ago, has proved very successful as a bridge between industry and research Institutes. Its efforts have reduced the gap between the research outcome and its application. The foundation picks up simple problems from Industry, say if *the chimney installed at the top of a house by a certain company does not work so efficiently*. The foundation takes such a project to the relevant research institute which solves this problem and produces a chimney of a better and desired efficiency. There are host of such small or large projects which the foundation handles.

The Steinbies Foundation has branches throughout Germany and even in foreign countries and has proved very effective in providing means of efficient application of research to a better Industrial production[26].

A brief description of this foundation is given below. It is very much hoped that such a scheme if introduced in Pakistan will indeed be very useful for deriving economic benefits of basic research.

STEINBEIS FOUNDATION (GERMANY)

For 25 years the '*Steinbeis Foundation for Economic Promotion*', established in 1971, has provided a bridge between academia, research bodies, politics and industrial companies with great success.

Autonomous, flexible, decentralized, customer-oriented; these are the guiding principles upon which the work of a network of more than 370 Steinbeis transfer centres is founded, most of them based at or near institutions of higher education. These Transfer Centres have immediate access to a pool of more than 3400 professors, engineers, natural scientists, experts on industrial management and designers, covering an enormous range of specializations. Thus the foundation can engage the right specialists to work on each project, meaning that they can concentrate on the particular needs on the spot - no matter how specific.

Research and Development:

Germany is in the fortunate position of having an excellent research and development infrastructure. The Steinbeis Foundation acts as an interface between academic researchers and businesses. With more than 3,400 specialists in all key technologies, it can offer the first-hand access to direct, up-to-date technology transfer that can strengthen the market position and give a lead over other competitors.

International Technology Transfer:

For many years, multinational companies have been pushing ahead with the process of globalisation, and smaller companies now face the task of catching up with them. The most important roles of the foundation being the provision of assistance to small and medium-sized enterprises to enable them, too, to successfully penetrate the growth markets of the future, for example in Asia or the USA. The Foundation maintains an international network of links both with financially secure partners for joint business ventures and projects and with leading research and business institutions. The Foundation can thus extent the benefits to its clients from this "borderless transfer".

Business Promotion:

The federal state of Baden-Württemberg provides funding for new and established businesses in the form of specifically targeted financial aid programs. The Steinbeis Foundation advises during the application stage, and assists and supports during implementation of the project. The task of evaluating and advising projects deemed suitable for funding is in the hands of the Government Commissioner for technology transfer, Professor Löhn, who assesses companies on the basis of their innovative, market and competitive potential.

During 2,000 the Steinbeis network completed more than 19,000 (nineteen thousand) projects with a turnover of more than EUR 80 millions. The Chairman of the Board of the Steinbeis Foundation is Prof. Dr. Johann Loehn Baden-Wuerttemberg, Government Commissioner for Technology Transfer.

CONCLUSION

The sustainable development of a country, and this includes the member states of COMSATS, greatly depends on the sustainability of the high merit R&D institutions which can provide strength to economic needs of the country. The important factors for the sustainability of R&D can thus be listed, among others mentioned earlier:

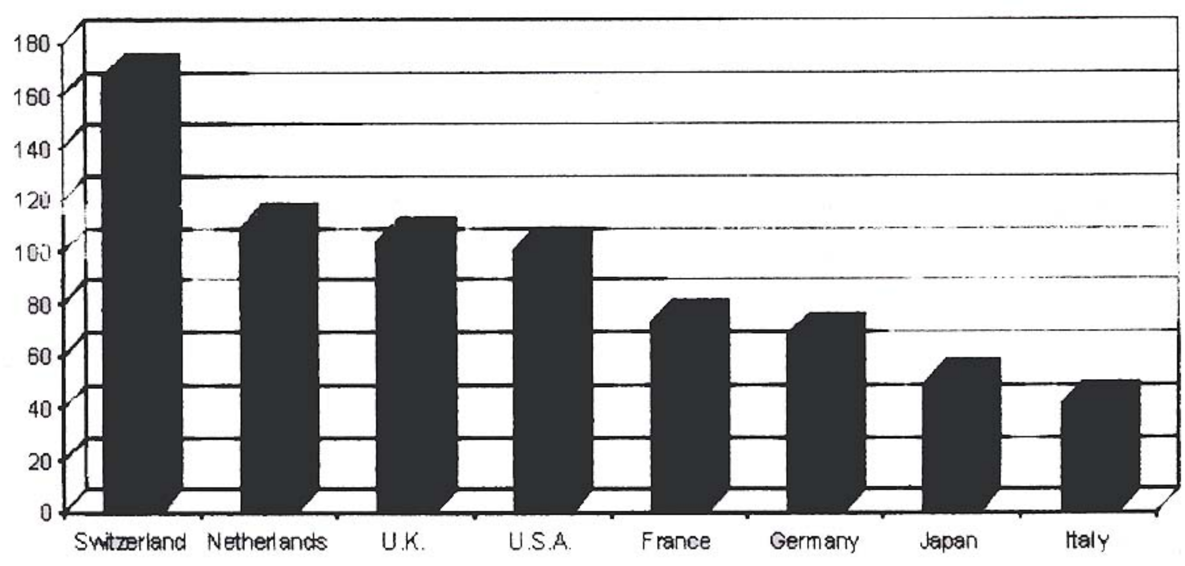
- Establishment of Research Quality of R&D institutions capable of giving strength to economy of the country. Thus quality more than quantity has to be stressed in such institutions.

- Merit, scientific ethics and a correct vision is necessary for continuous supply and availability of well qualified and trained scientists. To ensure sustainability of the institutions rules must be ensured for continuously preparing qualified and competent persons for replacement of the retiring individuals.

- Proper utilization schemes of research for applications for public use to solve the problems for common man. Foundations specialized in the applications of scientific research for industry in the shortest possible duration between the outcome of research and its application. Steinbeis Foundation in Germany is one such example well suited to such needs.

- A proper level of education in the country, the “Central Factor” on which all the above factors depend is education, a balanced combination of low and high education is necessary, not just a mass level lower education. Research based higher education is necessary for the production of eminent leaders and innovators for progress of the country concerned.

REFERRED FIGURES IN THE PAPER



Note: The study was conducted over a 14-year period and covered 79 countries (4000 journals). The Relative Citation Impact (citations divided by publications) gives some measure of the quality of the average paper.

Figure - 1: Research-Papers Per Person of Various Countries

	Nation	Citations Per Paper	Number of Papers	Total Citations
1.	Switzerland	5.66	55,213	312,564
2.	United States	5.03	1,239,188	6,234,187
3.	Netherlands	4.45	80,016	356,025
4.	Sweden	4.38	61,072	267,685
5.	Denmark	4.38	30,719	134,616
6.	United Kingdom	4.19	300,577	1,259,427
7.	Belgium	3.94	38,095	150,206
8.	Finland	3.93	26,998	106,151
9.	Canada	3.83	167,326	641,114
10.	Germany	3.78	258,946	979,823
11.	France	3.66	197,816	723,156
12.	Austria	3.54	24,388	86,275
13.	Israel	3.45	39,977	137,980
14.	Italy	3.42	116,534	398,285
15.	Norway	3.30	19,814	65,305
16.	Australia	3.23	85,215	275,599
17.	Japan	3.18	280,855	892,029
18.	New Zealand	2.94	17,015	50,007
19.	Ireland	2.78	9,233	25,630
20.	Spain	2.72	73,224	199,443
21.	Hungary	2.55	14,768	37,724
22.	Portugal	2.40	7,135	17,097
23.	Chile	2.31	6,666	15,366

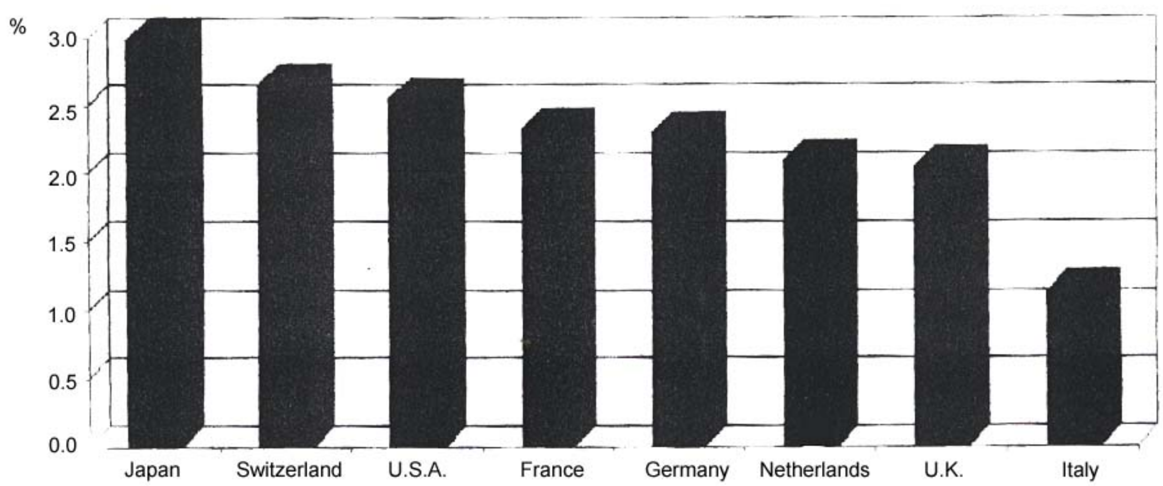
Dated July 7, 1997

Figure - 2: Nations Ranked by "Citations Per Paper (C.P.P)" (1992-96)

Country	R&D investment As % of GDP
Japan	2.98
Switzerland	**2.66** (1)
U.S.A.	2.55
France	2.33
Germany	2.30
Netherlands	2.09
U.K.	2.05
Italy	1.14

Source: *Main Science and Technology Indicators*, OECD, February 1998
Note: (1) Figures are for 1992, and are the most recent available

Figure - 3(a): Investment in Research and Development As a Percentage of GDP



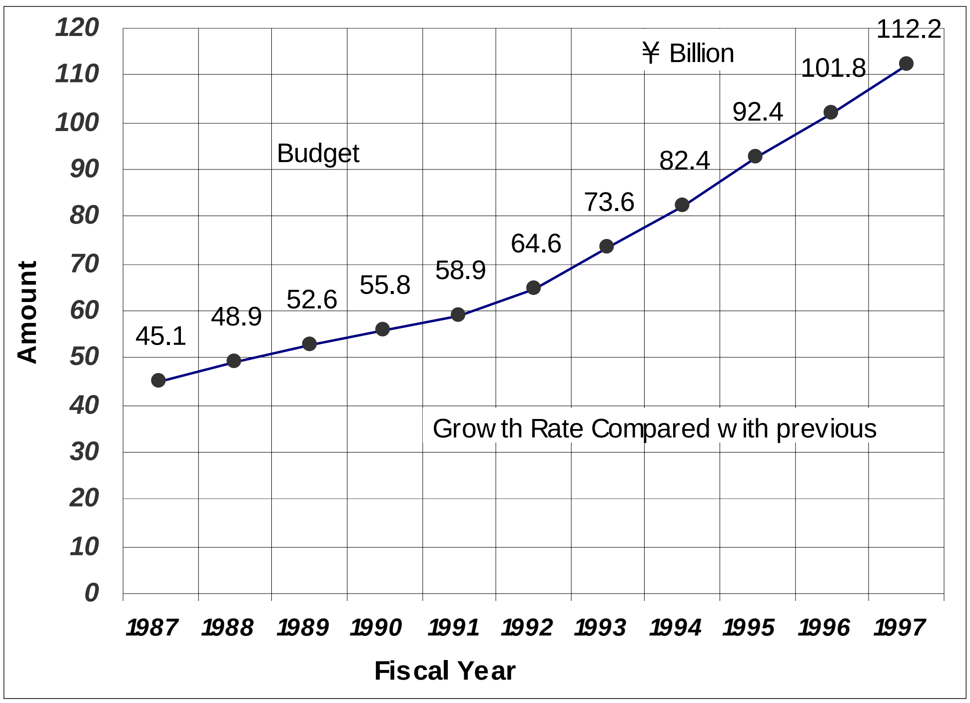
Source: http://www.geneva.ch/research_development.htm (9/17/1999)

Figure – 3(b): Investment in R&D as Percentage of GDP of OECD Countries

YEAR/ ORGANIZATION	TOTAL	UNIVERSITIES	RESEARCH INSTITUTES	COMPANIES
1975	310,111	134,458	29,049	146,604
1985	447,719 [1.44]	180,606 [1.34]	36,016 [1.24]	231,097 [1.58]
1996	673,421 [2.17]	242,862 [1.18]	46,459 [1.60]	384,100 [2.62]

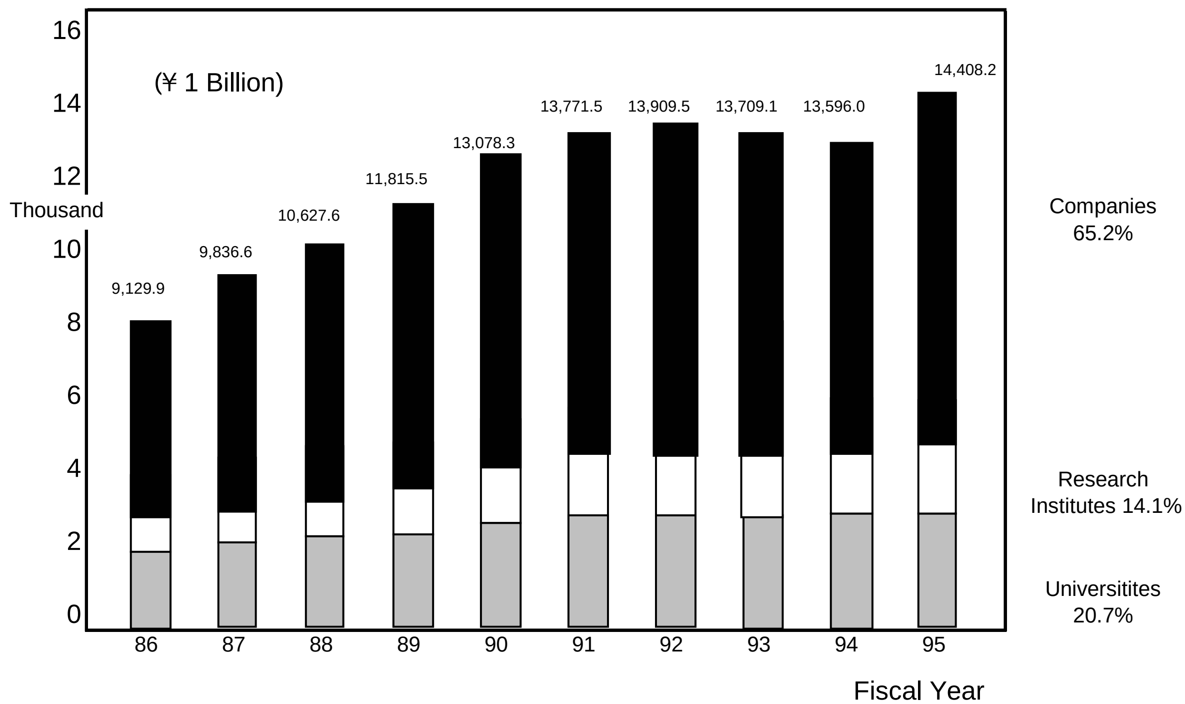
Note: Figures in Parenthesis denotes rates of increase {fiscal 1975=1.00}
Source: Management and Coordination agency , "Survey of Research and Development" (1996)

Figure - 4: Increasing Trends in Number of Researchers in Universities, Research Institutions and in Companies in Japan



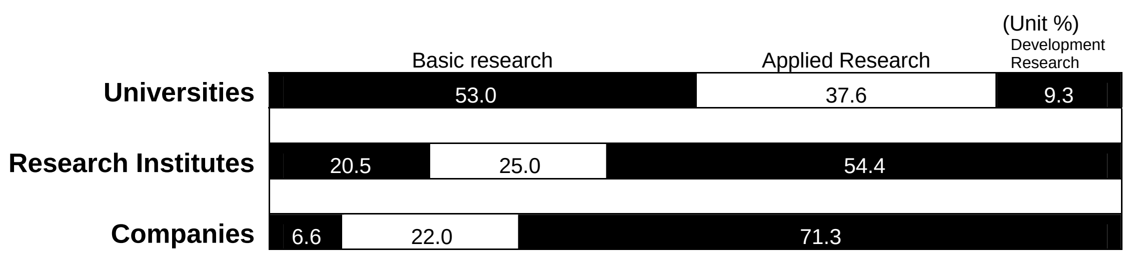
Source: MESSC

Figure - 5: Increasing trends in budgets for Grants-in-Aids for Scientific Research in Japan



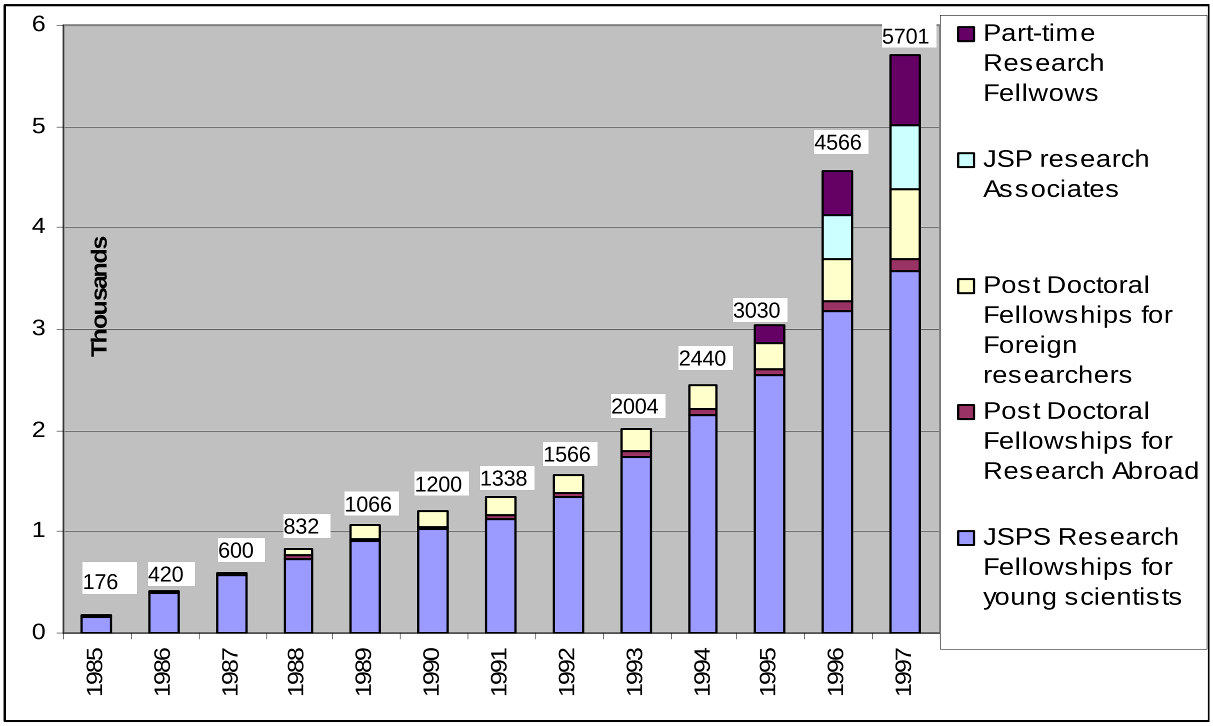
Source: Management and Coordination Agency, "Survey of Research and Development"

Figure - 6: Trends in Research Funding for Universities, Research Institutes and Companies



Source: Management and Coordination Agency, "Survey of Research and Development" (1996)
Note: The Figures may not add upto 100% because of rounding

Figure - 7: Relative Distribution of Research Expenditures for Basic, Applied and Developmental Research for Universities, Research Institutions and Companies in Japan



Fiscal Year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
JSPS Research Fellowships for Young Scientists	156	400	580	740	916	1020	1128	1336	1744	2150	2540	3170	3570
Postdoctoral Fellowships for Research abroad	20	20	20	20	20	25	35	45	55	65	75	100	125
Postdoctoral Fellowships for Foreign Researchers	0	0	0	72	130	155	175	185	205	225	255	420	680
JSPS Research Associates												440	640
Part-Time Research Fellow											160	426	686

Figure - 8: Increasing Trend in Post-doctoral Research Fellowships from 1985-97 in Japan

	1981-1985		1984-1988		1987-1991		1990-1994	
	Share	Ranking	Share	Ranking	Share	Ranking	Share	Ranking
Agricultural Sciences	11.3	2	11.6	2	12	2	11.5	2
Astro Physics	1.7	10	2.8	9	3.4	6	3.2	7
Biology & Biochemistry	6.7	3	7.4	3	7.6	3	7.8	3
Chemistry	10.2	2	10.5	2	10.5	2	10.3	2
Clinical Medicines	2.4	7	3	6	3.7	5	4.4	3
Computer science	3.3	5	3.8	5	3.1	6	3.2	6
Engineering	7.9	3	7.6	3	7.7	3	7.2	4
Ecology & Environment	1.8	8	2.1	8	2.2	8	1.9	9
Geosciences	2	8	2.3	7	2.5	7	2.4	7
Immunology	3.35	6	4	4	3.9	5	4.5	5
Molecular Biology & Genetics	3.9	5	3.5	5	3.9	5	4.2	5
Materials Sciences	9.1	2	11.6	2	12.5	2	12.1	2
Mathematics	3.6	6	3.8	6	3.8	6	3.5	6
Neuro Sciences	3.3	7	3.7	6	4.3	6	5.2	5
Physics	7	4	7.9	3	9.4	2	8.9	3
Plant & Animal Sciences	4.6	5	5	6	5.1	5	5.1	5
Pharmacology	6	4	7.2	4	7.7	3	7.5	3
Micro Biology	5.3	4	5.4	4	5.6	4	6.1	4
Multi Disciplinary Fields	2.3	7	2.7	7	3.4	7	4.3	6
Total	5.3	4	5.7	4	6.1	4	6.3	4

Source: Institute for Scientific Information, "National Science Indicators on Diskette, 1981-1996"

Figure - 9: Japan's Ranking and Shares of World Totals for Citations from Research Papers in Various Scientific Fields

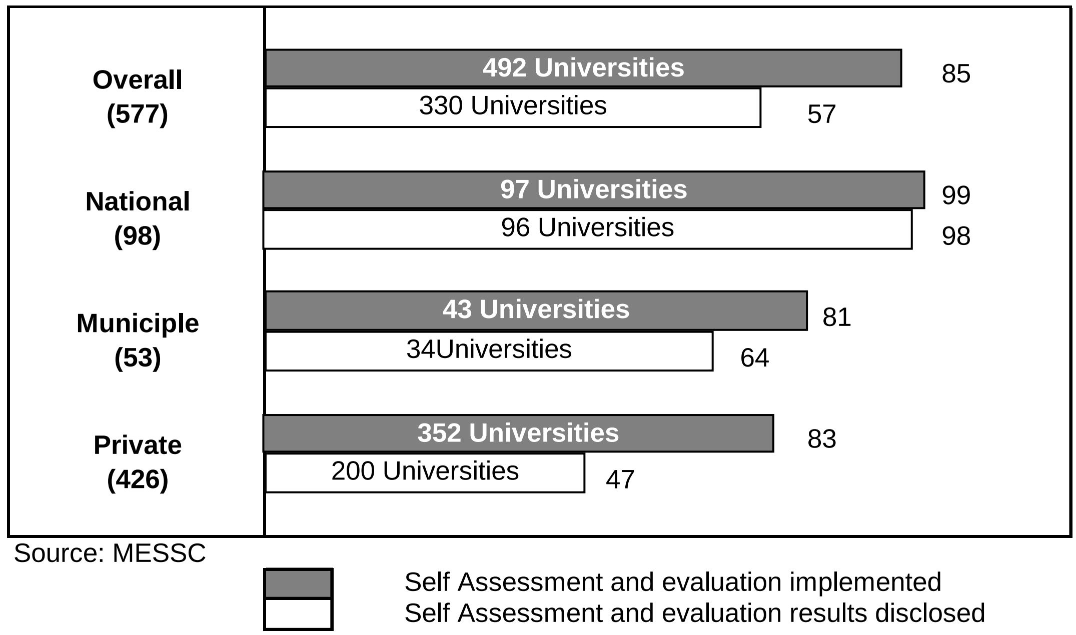


Figure - 10: Self-Monitoring and Self-Evaluation in Universities in Japan

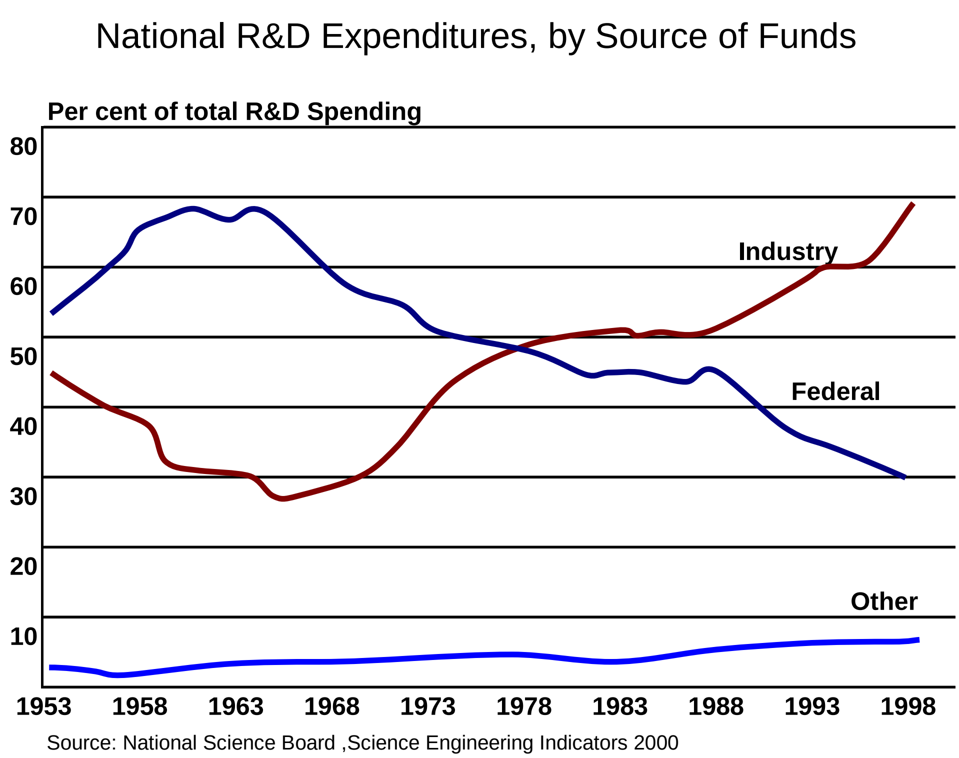
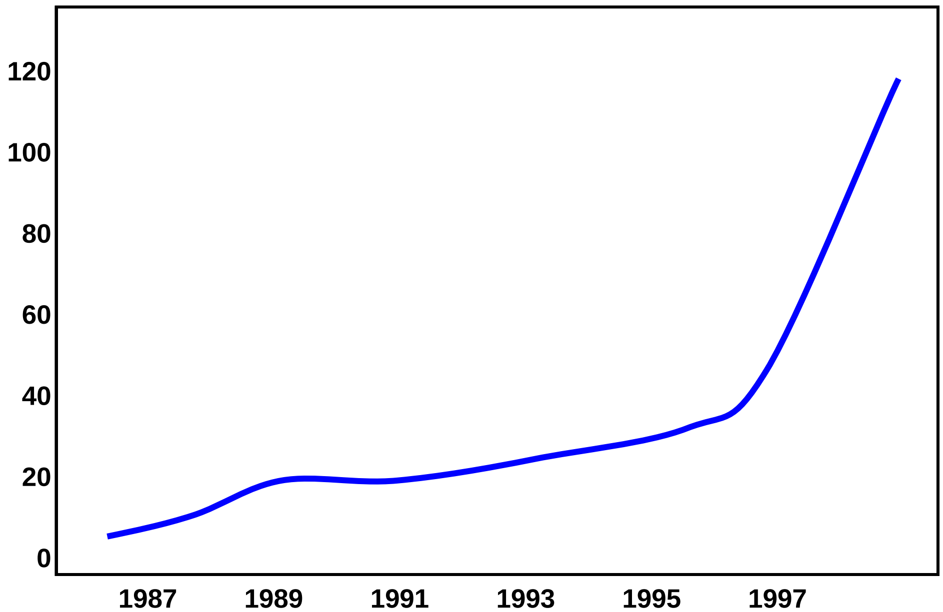


Figure - 11: Percentage of R&D Spending by Industry, Federal Govt., and Others in the United States



Source: National Science Board ,Science Engineering Indicators 2000
http://www.nsf.gov/od/1pa/news/press/00/seind_medcharts.htm (10/4/01)

Figure - 12: Increasing Trends in Number of Citations on US Patents to Scientific and Technical Articles During 1987-1998

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RESTRUCTURING OF RESEARCH & DEVELOPMENT IN PAKISTAN

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BACKGROUND

A large number of Research & Development Organisations have been established in Pakistan. The Federal as well as the Provincial Governments have made considerable investments, but the financial support has not been consistent and continuous. The private-sector industry has been critical of the R&D system as a whole. They claim that the R&D institutes have fallen behind the general expectations.

In the first decade after Independence, there was considerable discussion regarding the establishment of Research & Development within the universities or outside. The view that prevailed was based on the argument that Pakistan, with its limited resources, should concentrate on adaptive research and only a limited amount of fundamental research. The adaptive research, to benefit the industry, was expected to be done in specialised R&D institutions set up, outside the universities. The universities were to concentrate on basic research. However, when the R&D organisations were set up, their heads and other senior scientists had to be inducted from the universities. They lost the link with teaching, but could not establish the link with industry. The entrepreneurial approach could not be achieved. This resulted in research projects being selected according to the personal aptitude of the scientists, in most cases without any relationship with the needs of industry or product-improvement.

The budgeting and funding of these organisations also did not give any incentive for taking up research-projects based on market-demand or survey of the industrial need for technology. Where any research was done, it was to produce publishable papers in scientific journals. There were some attempts at import-substitution and reverse-engineering. Only a few of these had any impact on industry.

The de-linking from the market-demand for technology is illustrated by the approach of most R&D organisations, with only a few exceptions. It is interesting to note that, before 1947, the Agricultural College at Faisalabad did considerable practical research, which resulted in improved agricultural practices and improved seeds as well as new varieties of wheat and cotton. In those days, the professors at the college were directly involved in extension work. They were active in keeping contacts with farmers and taking the results of their research *directly* to the farmers, through many devices including demonstration-plots. After 1947, the agricultural college evolved into a university but the Government created a separate department for extension work. The link with the farmers was considerably weakened in this manner.

PCSIR also expanded considerably after its inception in 1949-50 and it was able to establish a large number of laboratories for applied search in a variety of scientific disciplines. This, in itself, was quite commendable. However, its impact on industry is still on the low side. Very few industrialists even attempt to use its facilities. It must be mentioned, to the credit of PCSIR, that in order to create this link with industry, a new organisation called STEDEC or Science and Technology Development Corporation was created. This organisation was to market the technology and services available with PCSIR. This experiment was somewhat successful, but STEDEC fell into the trap of producing goods based on PCSIR research and marketing the products from the pilot-plants of PCSIR. STEDEC can boast of a commercial approach, but it can hardly claim any technology-sales to industry, which was the real purpose for which it was created. The higher objective of promoting interaction between scientists and private industry and bringing projects from private industry to PCSIR, for research and development, could not be achieved.

Some R&D organisations were attached with departments like WAPDA. It was hoped that the basic financial strength of the parent body and its own technological needs would create a symbiotic relationship. In most cases, this could not be achieved, as the personnel policies of the parent body were also adopted for the attached research organisation. At times, this resulted in perverse situations: the unwanted officers from the parent organisation were posted to the attached research organisation. This created a serious morale problem within the research organisation and, in fact, hindered research. The Rawat laboratory, among many others, visibly suffered from this approach. The grass could not grow

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under the proverbial Banyan tree.

Administrative Aspects: A study of public-sector corporations, in general, and research organisations, in particular, reveals an unimaginative approach toward managerial and organisational issues. A survey by the Committee on Public-Sector Corporations, Autonomous and Semi-autonomous Bodies, headed by the author, collected a considerable amount of data. The analysis brings out some interesting points applicable to the research organisations and their effectiveness. The relevant findings follow: -

1. **Selection of Heads.** Selection of heads of research organisations was found to be highly discretionary. In 69% of cases, the selection was made without any standard procedure. In most cases the concept of search-committees to select a panel of names, out of which the government could select the head, was not even known.

2. **Tenure of Head of Organisation.** The survey also revealed that in 77% of cases the heads spent less than three years in the organisation. This points towards the desirability of introducing a fixed-tenure system in the research organisations, so that security of tenure is guaranteed under law.

3. **Governing Board.** In a large number of cases, the chief executive was also the head of the governing board. The meetings of the governing boards were rare and, in any case, not, regular. The governing bodies were performing only a ceremonial function and could not contribute to accountability or performance-evaluation. The procedure regarding appointment of head of organisation could be institutionalised only by amending the governing-law or charter. There was a view that the chief executive should not be the chairman of the governing body. It was also noticed that there was no real incentive for the members of the governing boards to attend the meetings. In the case of commercial concerns, the governing board consists of directors who are the main shareholders and can be treated as owners. They can hold the C.E.O. of the company responsible and accountable.

   Although the idea within the government was based on the same format, but it was not implemented properly, with the result that in most cases there was not even the beginning of the corporate culture, which the designers had hoped for. In a scientific organisation, the corporate culture and accountability is difficult to achieve. However, strengthening the governing boards promises to be an effective method of achieving the twin objectives of accountability and a corporate culture, which is currently lacking in R&D organisations. In line with the recommendations of the Committee referred to above, it would be highly appropriate if: -

   a. The members of the Governing Boards have experience and qualifications having a clear relationship with the goals of the organisation and its speciality.
   b. The members of the G.B. are of similar rank as the head, or in higher grade, so that they can be objective.

4. **Performance Evaluation.** Inadequate performance-evaluation by the governing boards or the administrative ministry was clearly brought out, according to the data. Only 36% of the organisations surveyed had conducted any study for improving efficiency. There were also serious audit objections in the scientific organisations that had not been properly addressed or rectified. Numerous disciplinary inquiries were pending in 31 % of the organisations. On the basis of this data, one can consider the desirability of the following possible steps: -

   a. Performance-standards should be worked out by various organisations and duly approved by the governing boards.
   b. A system of cash-incentives has to be introduced.
   c. Merit Orientation & Outside Interference. The study found that outside factors are adversely influencing the functioning of organisations: 74% of organisations reported external factors hampering their performance. It was also apparent that ‘Merit’ was being ignored because of the traditional ‘Sifarish’ system, which had attained the proportions of an epidemic.

5. ***Science Policies*.** A number of science and technology policies have been made. Each policy resulted in some boost to the S&T system, although no policy has been implemented, in full, so far. The first Science Policy in the eighties resulted in the formation of a number of new R&D organisations and, ultimately, the ministry of science & technology; before that, it was only a wing in the ministry of education. The National Technology Policy of 1993 had an interesting angle to it, as the Pakistan Cabinet approved it and had an Action Plan attached to it. The cabinet also approved this and, at least, the first instalment of funds was also provided for implementation of the Action Plan. Among many issues, it identified a number of problems faced by the R&D organisations. These included lack of autonomy, poorly defined missions, lack of resources, lack of co-ordination and co-operation among R&D institutes and isolation from the client base.

6. ***Findings of Consultants*.** The Ministry of Science & Technology was able to get the advice of consultants, with the help of international organisations like the UNDP and the World Bank. The report of consultants in June 1992 prepared by Carl Erik Wegener and Jose Adeodato de Souza Neto, sponsored by UNDP, brought up some very relevant points. Some of their findings and recommendations follow: -

> "*The linkage between the institutes and their clientele is generally deficient, if at all existing…The result of the lack of communication is that the individual scientists define and select the R&D projects, based upon their own interpretation of the needs of the users or on the basis of import-substitution…..A very limited percentage of the developed products and processes are utilised by the productive sector; however no exact data are available*."

7. ***Supply and Demand of Technology*.** A consensual finding in current literature is that 75% of the successful industrial innovations are of the "pull" type. Marketing or production-people originally proposed them. The important feature of this method is that it detects the innovations that the market is willing to pay for.

8. ***Current Thinking.*** An interesting possibility for restructuring Research & Development has lately opened up in the country. This is because of a lot of interest being shown for the development of Science & Technology in the country and the considerable increase in the allocation of resources for science. There is a clear perception in the advisory boards set up by the Ministry of Science & Technology that restructuring has to take place first. Otherwise, the money will not be effectively spent and the science system as a whole might be blamed if, in spite of heavy allocation of funds, the output of R&D institutions falls below expectations. I will list below the salient features of the recommendations already made by the Review Committee on Restructuring. In fact, the measures suggested by the Review Committee have already been incorporated in a draft law, which has been circulated to all the organisations under the control of the ministry of science, for comments and suggestions.

   a. One of the new approaches is to form a Science & Technology Board of Management. This Board will become an effective arm of the ministry, to implement national science policy. The Board will have chapters or branches in the major cities, in order to deal with the R&D organisations on a regular basis. It will have the capability to analyse the work done by any R&D organisation and institute regular performance-evaluation. At the same time, the Board will have no power to interfere in the day-to-day functioning and decision-making of the R&D organisations.
   b. The concept of the Chief Executive Officer of the R&D organisations has been introduced. The head will have full powers of hiring and firing. The overriding goal will be to orient the work of the organisation, so that its research efforts are useful to the relevant industry. The success or failure of the C.E.O. of the R&D organisation will be judged from the usefulness of the services of the organisation and its capacity to sell new ideas and technology for product-improvement.
   c. The R&D organisations will be expected to meet a percentage of their expenses through Internal Cash-Generation. The revenues earned will remain under the control of the organisation and will not be credited back to the national exchequer.
   d. The requirements of Working Capital for each R&D organisation will be worked out. The approved amounts will be provided as Working Capital, so that the organisation can have a business-like approach and capability. There will be a marketing wing in the organisation, to

boost sales of its products, services and technology.

e. The cash generated by the organisation will be used to enhance its productivity and to reward its employees, according to an approved proportion. The income from patents will also be retained.
f. The R&D organisation, after strengthening and provision of Working Capital, will be expected to meet some of the expenses, according to an approved schedule. In accordance with this approved programme, the non-development part of the budget will be reduced in easy stages. This will put enough pressure on the organisation and its C.E.O. to husband the resources in a business-like manner and to reach out to prospective customers and clients. If the revenues are less than the (non-developmental) reduction, the C.E.O. will have to reduce staff by laying off. This is admittedly a controversial measure, but many countries have already adopted this method. New Zealand, Australia, South Africa and India can be cited as examples for adopting this measure.
g. In case the Board of Management is established, there will be no need for individual boards of governors. Instead there will be a number of standing committees for intellectual interaction and collective decision-making.
h. The new system envisages a tenure-system for the Chief Executives heading the R&D organisations.

CONCLUSIONS

Research and Development capabilities exist within the country in a variety of disciplines. The link-up with industry will be beneficial to the R&D sector in a big way. The link-up can be achieved only through a variety of reforms *within* the science sector, as it requires a sea-change in the attitude of the heads of R&D organisations. The institution of performance-evaluation, peer-review and creation of incentives, through funding streams allocated on the basis of performance, can do the job.

PHYSICS, EDUCATION AND TECHNOLOGY

*Dieter Blechschmidt**
*Hafeez Hoorani***

ABSTRACT

This article stresses upon a relationship between Physics, Education and Technology. It also relates the economic prosperity of a country to science and technology. The emphasis is placed on scientific collaboration among various countries. The authors are motivated by their experience of working with European Organization for Nuclear Research (CERN), which is based in Geneva, Switzerland.

INTRODUCTION

Human beings are the ones with critical conscious in the Universe. The statement is true at least of the present knowledge of the Universe. The human race is capable of controlling nature through the power gained by science. Science is the acquisition of knowledge. Its applications have helped the human race find the cure of number of fatal diseases. It has helped find solutions for good and clean environment. Science is motivated by pure curiosity and the quest of mankind to understand the totality of its existence. Therefore, science is a key element of mankind. On the other hand, physics is the knowledge of matter and its interactions and is a key element of science. By deduction, physics is thus a key element of mankind.

Philosophers of the antique, like Socrates, Plato, Aristotle, and Democritos laid down the foundations of present-day science based on a few axioms and rational deductions. One of the prime examples is Mathematics. The Oriental philosophers and scientists developed Mathematics for its first important practical applications such as: astronomy, geodesy, navigation, etc. Using the strong base, provided by the Oriental scientists, the Western philosophers laid the foundation for Mathematics as a powerful scientific tool. Most notably Kant, Schopenhauer, Descartes and Leibnitz have advanced the above-mentioned idea. Mathematicians like Peano, Gauss, Euler and Neumann developed their science into an indispensable tool for physics.

ROLE OF PHYSICS

Physicists applied and improved Mathematics as a necessary tool to formalize their research, ideas and the philosophical contents of the physics world in order to better understand it. The experimental aspect of physics was developed to verify the theoretical predictions of physicists. The spin-offs from experimental physics were developed for practical applications leading to industrial revolution and our present standard of living. These applications from experimental physics to real life gave birth to technology.

Physics discoveries soon opened more questions than could be answered. Physics and physicists were often in contradiction to the dogmatic contents of spiritual sciences. The earth is not the centre of the Universe, the Universe may have come into existence by the “Big Bang” and it was not created in seven days. In contrast to spiritual sciences, physics must pass the test of reality and should be free from moral or ethical objectives. However, even the most agnostic modern scientist must admit that the beauty and the simplicity of the laws governing the Universe cannot be taken as a mere fact. The beauty of the living creatures cannot be explained by Darwin’s theory only. We must concede that physics does not explain everything. As far as ethical or moral aspects are concerned, there are potential conflicts arising from the applications of physics which must be addressed.

SOCIOLOGICAL CHANGES DUE TO SCIENCE

The problem of science is that it is a product of human mind but excludes inherently the notion of any human feelings. Physics thus cannot be developed without regard to the overall concerns of mankind. The evolution of technologies associated with physics has drastically changed the conditions of life over

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the last 150 years, a very short period in the history of mankind. The sociological changes caused by physics and its direct linkage to technology give rise to the following cycle:

- Development of Technology,
- Industrial Applications,
- Better Economy,
- Increase of Wealth,
- Improvement of Basic Infrastructure,
- Social Stability, Peace and Better Education.

The above cycle has divided our world into the "Industrialized Nations" and the "Countries of the South". The difference of standard of living between the "Industrialized Nations" and the "Countries of the South" will further increase without urgent affirmative action. One can break the vicious cycle by investing heavily in the basic infrastructure of a country, in particular the education and health sector. There are many talented people world-over but without education they will remain talented but uneducated. They will be unfit for science and for the improvement of their country's living standards. Proper basic infrastructure will stop the emigration of competent people and will result in generating expertise. Availability of talented and education people will give rise to more economic possibilities; improve Gross National Product (GNP) and the living standard of the nation.

The industrialized countries spend 2 to 2.5% of their GDP on Research and Development and utilization of Science and Technology. In contrast, the allocation in most of the countries in the South is negligibly small. Today 95% of the new science in the world is created in the countries comprising only 20% of the world's population while the remaining 80% contributes only 5% towards it. This lopsided distribution of scientific activity creates serious problems not only for the scientific community in the countries of the South but also for the development of these nations.

POSSIBLE SOLUTION TO SOCIOLOGICAL PROBLEMS

The South spends out of its scares resources on education but the trend of emigration of trained and educated people is causing most of the investment to go to waste. Governments of the South thus should make a concerted effort to provide opportunities to their scientists to work for their home country. Education is expensive enough for the poor countries of the South and appropriate investments in science and technology infrastructure are often seen as prohibitive on a short time-scale. However, there are many fields where affordable investments are possible, such as data communications, software and database development, engineering, and electronics design.

The real solution to the problem is to create a "political climate of priority" for physics, education and technology. This means investment in education, science and technology. Another important aspect is to invite scientists who have left their home countries. They should be encouraged to contribute towards solving problems confronted by their home countries.

- Sponsorship of fellowships or similar
- Participation to reviews
- Delegation and subcontracting of research work abroad

The government should use the World-Wide-Web to access electronic databases of emigrated scientists from around the world to contract emigrated scientists resident in foreign countries and to make them aware of the problems and task that await them in their home countries. Another possibility is to complement the education of scientists, through participation in international scientific collaboration such as CERN, FNAL, GENOM, provided they find it attractive to return to work in their home country.

ROLE OF CERN

CERN has a tradition to train some 1000-1200 young scientists per year. Typical training period is 1-3 years. The training at CERN provides "hands-on" experience in modern technologies and in an international environment with clear objectives and deliverables. The selection criteria are strict and CERN supports the idea of trainee returning to the institute of origin, thus avoiding brain drain. CERN provides particle beams and laboratory infrastructure to the international Physics-community for high-energy particle Physics research. The CERN does not provide the particle-detectors (experimental devices) which have to be conceived, funded, built and operated by international collaborations, hosted by CERN. These detectors, used with the accelerators at CERN are "super-microscopes" to analyse the constituents of sub-nuclear matter. Their size, complexity and cost imply a truly worldwide international collaboration in which many "Countries of the South" are already participating members.

CERN, as an inter-governmental Physics research institution (not funded to provide industry with new products) has made a number of important technological innovations mainly to cover its own needs or as a by-product of its expertise in the fields of robotics, micro-and macro-mechanics, electronics, medical facilities, super-conductivity, networking and computing (worldwide web), carbon-fibre structures, geodesy, elimination of nuclear waste, ultra-high vacuum, PC boards, ion sources, RF systems, etc..

CONCLUSIONS

Science and technology are undoubtedly the principal agents of progress in the modern world. True economic independence is not possible without a significant degree of autarky in science and technology. Science must become a component of the development of all mankind particularly the less developed ones. The countries of the South must realize that change is a natural phenomenon in human affairs and that development is incompatible with a static and rigid view of the world. The spirit of inquiry to find the facts and rely upon them needs to be encouraged and propagated in the developing countries. As a final note the authors would like to give two quotations of Late Professor Abdus Salam, Nobel Laureate of Physics (1979) and the founder of International Centre for Theoretical Physics:

"…The Third World despite its realization that science and technology are the sustenance, and its major hope for economic betterment, has taken to science as only a marginal activity."

"…The Third World as a whole is slowly waking up to the realization that – in the last analysis – Science and Technology are what distinguish the South from the North. On Science and Technology depends the standards of living of a nation and its defense standing. The widening gap between nations of the North and the South is basically the "Science Gap". Now, while the South is making some purposeful efforts to acquire technology, very few of us have yet woken up to the need of acquiring science as well." "…It is just impossible to talk only of the technology transfer. One should talk of science transfer, first, and technology transfer later. … Unless you are very good at science you will never be good at technology."

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COMSATS 1ST MEETING ON SCIENCE AND TECHNOLOGY FOR SUSTAINABLE DEVELOPMENT (OCTOBER 8-9, 2001)

CONCLUDING REMARKS

The purpose of arranging COMSATS 1st meeting on Science & Technology for Sustainable Development was to share expert views of various scientists, technologists and researchers. This also served the purpose of discussing various roles and facets of science and technology. On the basis of these presentations, a number of conclusions and recommendations were made, which are briefly summarized hereunder:

- The 21st century is going to be a knowledge-driven century where, of all the resources, human resource shall assume greatest importance. Natural resources are as such no longer important in relation to the challenges and demands this century posed. It is how we transform them with the application of science and technology to fulfil our modern-day requirements that is significant. It is, therefore, important that knowledge and technology must go hand in hand. The excellence in basic scientific areas and their application in tandem with technology is the only way we can do away with the scourge of poverty in the developing world.

- Importance of Nuclear Technologies in relation to sustainable development cannot be overlooked. They have an enormous potential to address agriculture, human health and medicine, water resource, atmospheric and other issues related to sustainable development.

- Countries of the South should work together for poverty alleviation as the markets in the North will remain reluctant to address the real requirements of the poor and there is a dire need for indigenous absorption.

- From an educational research view-point, strategies should be developed so that universities are able to face the challenges from new emerging technologies. In this regard, there is an increasing use, significance and application of some emerging technologies likely to dominate the 21st century, like Nano-technology, Nano-medicine space technology, biotechnology & genetic engineering. There is also a need for the universities to have international collaboration in order to exploit new sciences and to equip them with upcoming technology.

- In this information age, IT is being applied in the fields like agriculture, health, education, human resource and environmental management, transport and businesses development. Communications and information technology have enormous potential, especially for developing countries, and in furthering sustainable development.

- To achieve prosperity, we need educated people and good infrastructure. In addition to this, the aim of achieving sustainability can be realized through the means of international cooperation.

- Importance of materials in the technological development process is very high, and no industry, machinery, or product can by-pass the thorough knowledge of the materials being involved in the process.

- Countries of the South have a variety of S&T policies on the part of their governments yet they failed to make an impact because these overlooked the concerns of the poor and rural people. It was stressed during the meeting that we must understand the concept of relationship between the society and S&T is different in the West. This is mainly due to their different rural and urban population distribution. Imported technologies are not only expensive but are also often ineffective in alleviating poverty in the South. Therefore, we need to rely on small sustainable technologies such as biogas prepared from manure and used for energy generation and cooking.

- An access to sound technologies is essential for sustainable development. The developing countries' need for the same is great, but it is hindered by the international technology transfer constraints. These impediments include lack of access to capital, a poorly developed banking sector, lack of long-term capital financing, high inflation rates etc.

- Technology transfer and adaptation require substantial investments and financing. These may come from either the public sector or private sector. The establishment of a venture capital fund and the creation of a technology transfer fund (TT & DF) may be the solution.

- There is an immediate need to indigenise technology at the grass root level to build rural economy as per environmental needs by rendering the much needed information and skills to farmers in agro processing and then supporting it with technical knowledge and financial help.

- Investment in high quality research endeavours would pave the way for a sustainable socio-economic development as the importance of quality of research is one of the most important facts in the quest for sustainable development.

- Biotechnology has huge potential for the developing countries, and its role in various fields like agriculture, medicine, genetics etc. is immense.

- Among other things, the critical area of restructuring R&D in Pakistan was also discussed. It was pointed out that the success can only be achieved in case drastic reforms are carried out within the R&D sector, and also if R&D organizations follow a "Demand Pull" rather than "Supply Push" strategy.

- In elaborating the role of planning for sustainable development, it was noted that the developing world is faced with common social problems and intricate economic issues such as those related to globalisation. The recommendations that were forwarded deemed regional integration and cooperation, capacity and infrastructure building for science and technology as essential ingredients for sustainable development.

- Communication is not merely a means of transferring news and information but in essence it also revolutionizes the whole human life. The advent of globalisation implies an access to information by people from around the world and the process has its attendant benefits and risks.

Based on the discussions and conclusions, a few recommendations are herewith forwarded for the reasons of their practicability and importance for developing countries:

COMSATS' RECOMMENDATIONS

COMSATS' appeals to the Countries of South to:

a. Allocate appropriate funds to make self-sustainable development a viable reality;

b. Foster short and long-term plans for implementing sustainable development, especially in Human Resources;

c. Undertake efforts to develop and introduce curricula that can integrate scientific, technological and liberal-arts education at all levels, so as to sensitise the public to the social dimensions of science as well as ensure their participation in development;

d. Take necessary steps to encourage the rapid development and induction of environment-friendly renewable-energy technologies;

e. Encourage pure and applied research in Biotechnology, in general, and agro-based technologies, in particular, so as to generate indigenous technology-based employment in the large rural areas of the

Third World;

f. Establish basic infrastructure in Information and Communications Technologies (ICTs), providing the population specially rural and remote areas to the global knowledge databases: national, regional and international markets, technology, raw material resources, etc. Governments should provide adequate support to ICT based companies through legislation, financing, as well as other enabling environment;

g. Encourage the growth and development of indigenous materials, as well as development of new engineering materials;

h. Following areas may be given top priority for accelerated growth and development:

   i. Human Resource Development (HRD) - Higher S&T Education
   ii. Information and Communications Technologies (ICTs)
   iii. Bio-technology / Agro-based industries
   iv. Water Resources