Science and Technology
Policies for Third World Countries

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his book begins with an attempt to analyze the historical perspective of the application of S&T to Development by adopting the criteria used by UN agencies at various international moots for S&T manpower and national expenditure on R&D, global expenditure on R&D and national commitments through establishing institutions for scientific research and development. This review shows that there is now great realization that a country should develop its own National S&T Policy and relevant Implementation Plan, in order to get optimum socio-economic development, and also to ensure that there is a mechanism for the periodical review and assessment, so as to align it with the plans for socio-economic development.

The levels of technological progress of the economies range widely from the underdeveloped to the almost developed, which implies that location of each country on the path of technological progress is different with varying endowment of S&T resources. As S&T environments are changing rapidly, therefore cooperation between countries at the regional and/or global levels is essential, not only because no country has sufficient resources for continuous economic growth, but also because the framework of a single nation is too narrow and too small for major undertakings. Therefore, cooperation between countries is necessary for better overall achievement and better quality of life. Without such cooperation, nations cannot assume coexistence and a promising future, together with sustainable socio-economic development. Cooperation, built on the basis of science and technology, is particularly emphasized in this book, in the age where knowledge is the most valuable asset at the levels of the individual organization as well as the nation.

The book highlights the facts that the concepts of sustainable development is urgently needed, to the world, bilateral and international S&T agreements is perhaps the main vehicle for effective cooperation in the above-mentioned broad areas, particularly in respect of training, higher education, exchange visits, networks of cooperating institutions, and joint purchase of technology.
Concept of Sustainable Development: This is the concept to meet the needs of the present generation without compromising the needs of future generations. The World Development Report 1992 suggested a threefold strategy for meeting the challenge of sustainable development.

- **Firstly**, policies that are effective in reducing poverty will help reduce population growth.

- **Secondly**, rising incomes and technological advances make sustainable development possible but effective environmental policies and institutions are essential.

- **Thirdly** investment is required in information and research as well as the adoption of precautionary measures, such as safe minimum standards, where uncertainties are great.

In addition, the regional and international S&T cooperation, through promotion of regional groups/international organizations and private foundations, is increasing day by day, for improving S&T capability for sustainable development. International cooperation, both south-south and north-south, is imperative for strengthening S&T applications for socio-economical development in the developing states. This sharing of human resources, using capacity building and technology transfer, is the basic foundation for development of S&T in a any developing country.

Some of the significant technologies suitable for the more developed of the third-world countries mentioned are:

Nano-Technologies: These technologies, at the scale of $10^{-9}$ are providing enormous benefits in many countries of the developing world. Today, prices instruments exist that enable us to control atoms. “Laser tweezer” (two beams of laser light) can displace individual atoms within a solid. An instrument called Atomic Force Microscope (AFM) can grip one atom and put it at another place. In biological materials, proteins are being studied using these instruments. This is a revolution in the area of medicine, and complete diagnostics and treatment of cancer and AIDS is in sight. New drugs are being invented that shall attack only the cancer cell as soon as it is produced and destroy it.
**Biotechnologies:** Biotechnology genetically improves crops using genes from diverse biological sources. Biotechnology is useful in combating food shortages and diseases. Third-world countries need to safeguard themselves from exploitation and erosion of their existing biodiversity by transnational corporations. Globally, biotechnology has registered an unprecedented 60-fold increase during the 1996-2006 decade. The leading countries in biotechnology crop plantings are United States (68%), Argentina (22%), and Canada (7%) with China (1%) and Australia (1%).

**Environment and Climate-Change:** The average global temperature has risen by 0.74°C during the last century, which is leading to environment dangers of disastrous change in climate. Climate-change has the potential to create global human disasters, ecological collapse and economic dislocation on a colossal scale. This trend is expected to rise in the future. This situation needs to be addressed urgently by the Third-World, in collaboration with the rest of the world.

**Mechatronics:** Mechatronics is “the synergistic combination of precision mechanical engineering, electronic control, and systems-thinking, in the design of products and manufacturing processes.” Some universities in developing countries including Turkey, Iran, Malaysia and Pakistan have already introduced this subject but there is need to do much more for usefully implementing it in industry.

**Endogenous Development:** Finally, a very important factor for effective human resource development is the need for the endogenous approach, i.e., to build on the existing indigenous base especially for the middle-level. In most countries of the Third-World, there is a vast reservoir of locally educated population, especially, from the lower middle class, which can be readily educated, trained and inducted for performing the middle-level S&T tasks as technicians and even junior technologists: In this way the local cultural roots can be utilized, strengthened and nourished, so as to provide a future productive generation. Drastic replacement of the local culture by an imposed S&T culture has only resulted in providing frustration and Brain Drain, in the long run.
It is hoped that administrators, planners and political leaders in developing countries would all find the material given in this volume useful as an aid for future development in making appropriate decisions in accordance with needs and demand of each country, thus leading to sustainable development.

Dr. Abdulaziz Othman Altwaijri
Director General
of the Islamic Educational, Scientific and Cultural Organization -ISESCO-
During the last hundred years the pace of Science and Technology in the developing world has grown so rapidly that the mode of life of the average citizen has changed dramatically. Things that were rare curiosities in the early nineties are today things of every-day use and even children’s toys have a futuristic tinge to them. New means of transport, new foods, new drugs and a new generation of wearing apparel and living accommodation are to be seen all around. In some cases, the changes are providing traumatic effects on man.

What Science and Technology is doing for us today can be summed up by noting that tremendous change has occurred not only in the type of Research & Development being done, but also in the regions and scales at which Science is now probing natural phenomena and coming up with new technologies.

The recent development in science and technology has made it possible to increase the crop yields substantially, and some countries beside meeting their food requirements, are exporting agricultural produce to the needy countries. The advancement in communication has made it possible to travel faster and to communicate quickly and be alert to the developments happening in other countries and regions. Also, science and technology developments have provided new medicines, new technologies and procedures to improve health and save lives from deadly diseases like Cancer, AIDS, while some major diseases that used to cause hundreds of death each year have been wiped out. Information Technology has provided access to information quickly and the research findings conducted elsewhere can be sifted and applied to the local conditions and endowment.

What is needed is to avail of the information, technologies and techniques freely available and to utilize them for the benefit and welfare of the people.

The Basic Means of R&D: Research and Development today is no longer confined to the ivory-tower scientific activities of two or three centuries ago,
where a single gifted individual could undertake a series of rewashable experiments using simple equipment and may be an assistant or two to help him. Research and Development today is a major enterprise that aims at the uplift of millions of deprived human beings living in far-flung areas of the world. For this enterprise, four basics essentials have been identified over the decades viz. High-level S&T Manpower, effective R&D structure and Organizations, adequate finances and above all, the national will to develop Science & Technology and apply it for the benefit of the human population.

Trained and qualified manpower is the basic need for development and prosperity of any country, developed or under-developed. Some countries with no natural resources and harsh climatic conditions are turning into developed countries, due to effective utilization of S&T manpower, particularly technicians. It is proven/observed that the large numbers of manpower result in faster pace of industrial and agricultural development. Another basic need is a firm commitment to provide funds for research and development on a continuing basis, so that researchers and engineers may work with zeal to achieve the assigned targets within given time-frame. The R&D structure and organizational set-up in most of the Third World countries is not upto international norms; for instance, in Pakistan there are tens of R&D institutes and experimental stations, but with no significant contribution to the national economy, because these are handicapped due to insufficient number of trained S&T manpower and financial shortages. It is also not necessary to have an institute for every discipline/scientific field; some countries can pool their resources to achieve common goals/objectives. Political will and structure play a very important role in the process of S&T development and its application to economic development. Educated political leaders in some third world countries have contributed positively towards this end.

Science Policies: When we take a quick look at the science-policies of some of the more scientifically developed countries in the Third World, namely Egypt, South Korea, Malaysia, Pakistan and Turkey, it appears that these countries have, in the main, based their S&T Policies over the last forty years on a combination of (i) S&T Manpower Development, (ii) improving the Export-potential of their Industries with, (iii) support by R&D activities in selected areas of special strength for the particular country.
In the vast majority of the Third-World countries (may be 55% of the total), there has been very little attempt at formulating an S&T Policy, other than sporadic efforts at import substitution, selective transfer of technology and similar activities.

The formulation of science and technology policies need the involvement of all stake-holders, particularly politicians, planners, scientists, engineers, industrialists and NGOs. S&T Policy prepared in isolation is just a good document with no objective to implement. Furthermore, policy should be supported by adequate financial inputs, appropriate trained manpower and infrastructure with targets/goals. Also, there should be provision to revise the policy periodically according to the changing needs.

**The difficulties of the Third-world countries in building an efficient S&T System:**

Majority of the third world countries do not have specific S&T Policy and thus no significant role of science in the socio-economic development. Even countries that have an approved S&T policy are not keen or hesitant to implement the policy in totality. It is treated as a nice piece of academic work, which is rarely updated or revised. Many countries governed by political leaders firmly believe in ad-hocism and are content to take actions, as and when required. The political leaders are either kept ignorant or willfully avoid taking decisions for building an efficient S&T system. It has to be realized that building of roads and bridges are not to be dealt at par with the building of R&D laboratories for biotechnology, natural products, electronics or for standardization of products, etc., and that these have to be continuously supported by sufficient finances, quality S&T manpower and services, in terms of equipment and tools, information technology and trained para-scientific staff. Despite the fact that in some countries the S&T sector is separately reflected in the development plan and the number of R&D laboratories established, yet the required level of development has not been achieved. This is a cause for serious thought by politicians, decision makers and S&T professionals alike.

*In brief, the difficulties observed in building an efficient S&T system are indicated below and elaborated further in relevant chapters of the book.*
1. The political leaders in the TWCs are unaware of the worldwide advancements of science and technology and their effective role in socio-economic development. They are engrossed with keeping themselves in power and least concerned with the importance of the education and S&T system.

2. Although each country has established a Ministry/Department of Science and Technology, National Science and Technology Council or Science and Technology Wing in the Planning Commission (some countries have all these institutions), but these have little role in the process of economic development.

3. The formation of S&T Policy is in the hands of bureaucrats and little consideration is given to the proposals/recommendations noted by the scientists working in the laboratories, academia and industrial units.

4. The allocations of funds for education, research and development are below the desired norms and moreover 85% of allocated funds are utilized for salaries and establishment.

5. The research laboratories, S&T organizations and service institutions are not answerable in real terms for their performance, as per their objectives and assigned functions.

6. Sufficient S&T information is available, free of cost, but it has to be sifted and matched with the endogenous knowledge and traditions.

7. In some cases, although the S&T Policy is approved by the federal government, it is not implemented to the full extent and another exercise starts for a new Policy (for example, S&T Policy in Pakistan was approved in 1984, another initiative for National Technology Policy started and approved in 1994).

8. Existing intellectual capital and R&D facilities available in the Third World Countries is not effectively utilized for solving common problems like improving agro-crop yields, disease control and quality of education. The bilateral/multi-lateral collaboration should be enhanced to resolve this.
Assessment and further actions/efforts to make-up the delay

It is well known that the majority of Third World Countries have poor natural and intellectual resources to provide basic needs to the vast majority of the population, in terms of food, education, health services and congenial environment. With these limited resources, how can Science and Technology provide relief. Also it is noted that these countries are in different stages of development (industrialized to low agricultural productivity) and the knowledge gained in the process of development is neither shared with the other less developed countries, nor are doors open to impart quality education and training for improving S&T capability of the least developed countries. There is a growing realization that they are at the tail-end of the S&T development and proper application of new inventions/techniques.

Just one example is sufficient to explain the situation. The USA engages less than 7% of the population in agriculture sector, beside meeting its food requirements and storage of food for years to come, yet it exports wheat, corn, soybeans and other agriculture products worth billions of dollars to the needy countries worldwide. On the other hand the third world countries employ over 75-90% of their population in agriculture, but need to import million tons of food grain to feed the population, so as to avoid famine and reduce poverty. This is a heavy drain on the limited foreign exchange resources.

In this situation, the political leaders may take joint actions to utilize S&T advancements in the process of economic development and improving quality of life of the people. The individual development plan should be based on three cardinal principles of faith, values and goals. Thus,

Each country should prepare a well thought-out comprehensive policy and plan for the development of S&T as an integral part of its socio-economic development, considering the various inputs required in terms of manpower, finances, S&T infrastructure and the main thrust-areas to work on during the plan period. The plan should be developed indigenously, with the full participation of all concerned stakeholders.

Development of technical manpower, in all categories from technicians to highly qualified scientists, is the need of the day. It has to be noted that this is a continuous programme and based on individual country requirements. It has to
be developed in such a manner that the trained manpower is effectively utilized, with proper incentives and not compelled to seek employment/migrate to the advanced countries. This is further elaborated in the relevant chapter of the book.

Indigenous educational base has to be improved with appropriate traditional knowledge, emphasis on science and practical training. Vocational centres be established for imparting training in various trades and working with new machines and tools. The apprenticeship program with relevant industry will further improve the skill of individual technicians.

The Third World Countries are mostly dependent on outside world for acquisition of new technologies and are essentially consumers of technology. The political leader and policy makers have to change the approach from a “consumer attitude” to “producer attitude” in the process of technology-acquisition.

Modern information technology tools have to be employed for determining S&T and educational indicators on a regular basis, and their utilization in the process of S&T policy formulation and implementation.

Bilateral and multilateral collaboration between the Third World Countries has to be worked out through various UN institutions and NGOs and by entering into S&T agreements with more advanced/industrialized countries, so as to produce sufficient well-trained manpower for application of S&T for development and well-managed enterprises.

Each country should develop a Fifteen-Year Plan involving all the concerned stakeholders and clearly identifying the mechanisms and resources for implementation. It is an essential pre-requisite to plan, implement and monitor the progress of S&T development.

One of the disturbing factors of the S&T Policies in most Third World Countries the absence of a feedback mechanism, which is an essential pre-requisite viz to plan, implement and to monitor. It is imperative to establish feedback mechanism while implementing the S&T policy.
Identifying Priority Areas

The World Development Report 1992 suggested a threefold strategy for meeting the challenges posed by sustainable development. Firstly, policies that are effective in reducing poverty will help reduce population-growth. Secondly, rising incomes and technological advances to make sustainable development possible, but effective environmental policies and institutions are essential. Thirdly, investment is required in information and research and the adoption of precautionary measures, such as safe minimum standards, where uncertainties are great. It is a must to direct the policies concerned with the development of human-capital, science and technology and innovation towards improving scientific-bases, raising per-capita incomes, employment generation and poverty-alleviation.

In order to achieve sustainable development, new and emerging technologies should also be included in the implementation plan. The following areas need to be given high priority, so as to have the necessary impact of the S&T efforts:

**Biotechnology:** Biotechnologically improved crops of soybeans, corn, tomatoes and cotton have been released commercially since 1996. Globally, biotechnology cropped areas have registered on unprecedented 60-fold increase during the 1996-2006 decade. The leading countries are United States (68%), Argentina (22%), and Canada (7%) with China (1%) and Australia (1%). Biotechnology also, has its use in textile, pharamental, starch and detergent industries and applications in control of diseases.

**Nano-Technologies:** Nanotechnology is the technology where small-sized materials (a few nano-meters) are handled, used and products made out of these. A nanometer (nm) is about 100,000 times thinner than the human hair. Today, precise instruments can handle molecules and atoms: “Laser-tweezer”, Atomic Force Microscope are being used in laboratories for treatment and diagnostic procedures for diseases like AIDS and Cancer. The numerous applications in a variety of fields include new materials, electronic devices, surface engineering, cosmetics, nano-tubes, and many others. The market of nanoparticles is around US $40 billion and it is envisioned to be a trillion dollar industry by 2020.
Environment and Climate Change: The indiscriminate use of various limited natural resources has continuously led to environmental degradation. For instance, the process of desertification and deforestation causes severe soil erosion, declining agricultural productivity, increased cost of production, change in temperature and rainfall, flight of population to towns and cities and, ultimately, leads to social and political instability. Emission of green-house gases is causing dramatic change in the atmospheric composition and the global climate will continue to warm rapidly over the decades and beyond. Climate change is a global challenge and requires a global solution, particularly by the industrialized countries, which are responsible for the increasing “blanket” of greenhouse gases. Climate change has the potential of human disasters, ecological collapse and economic dislocation on a colossal scale. Disastrous events, such as Tsunami in 2004 and 2005 earthquake in Pakistan, need to be countered proactively. This situation needs to be addressed urgently by the Third World countries, in collaboration with the rest of the world.

Hydrogen Fuel Cell: This technology promises to revolutionalize the transportation system, doing away with the ubiquitous presence of petroleum products. By using water as the source of hydrogen, produced by catalytic cleavage of the water molecules, clean energy can be produced by burning the hydrogen so produced.

Mechatronics: Mechatronics is “the synergistic combination of precision mechanical engineering, electronic control, and systems-thinking in the design of products and manufacturing processes”. Mechatronics and its application can enhance industrial productivity, in areas like molding and design, robotics, intelligent control, optoelectronic systems, automotive systems, bio-sensors etc. Some universities in the Third World countries, including Turkey, Iran, Pakistan and South Korea have introduced this subject, but there is need to do much more, for usefully implementing it in industry, agriculture and health sectors.

These and other such technologies hold enormous potential for rapid economic development, but such technology-based development is mostly by-passing the Third World Countries, and such opportunities are being lost. Active research and development collaboration among them needs to be implemented expeditiously.
1. INTRODUCTION

In the second half of the twentieth century, and specially after World-War II, a large number of developing countries, including several Islamic countries, have started re-building their national economies in accordance with the realities of the modern world. There seems to be a growing realization among them of the fact that economic development in today’s world is based on science and technology. This realization has led to initiation of some scientific activity in these countries, in the form of establishment of scientific organizations and institutes. Nevertheless, most of them are lagging far behind the developed world in these fields and, with a few exceptions, the role played by S&T in their economies is negligible.

The reasons for this situation are to be largely found, in most cases, in the absence of several pre-requisites for development of S&T, apart from the lack of the basic inputs of funds and other means. The following elements would seem to be of vital significance in the process of development, in general, and science-based development, in particular:

1. Education  
2. Planning  
3. Scientific Education  
4. Scientific Culture  
5. Science Policy  
6. Resources

Various international organizations began to look into these factors in the second half of the 20th century, as soon as the role of developing countries began to be realized as a significant factor in shaping the world’s future. The development and application of S&T was clearly in the forefront.

2. HISTORICAL PERSPECTIVE 1965 – 1985

Consequent to the UN Conference on the Application of Science and Technology for the Developing Countries in Geneva 1963, the UNESCO organized regional conferences in Lagos 1964, Chile 1965, and in India 1968. It organized the first Conference on the Application of Science and Technology for Development of Asia (CASTASIA I) in New Delhi in August 1968, with the objective “...to consider actions required to further the application of science and technology to the development of Asia”.

An attempt has been made to analyse the criteria adopted by various UN agencies for expenditure on R&D, global expenditure on R&D and the national commitment for scientific research and development. UNESCO has defined research and development as “any systematic and creative work undertaken in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this knowledge to devise new applications”. R&D expenditure excludes expenditure on S&T services and activities, in accordance with UNESCO recommendations.

The report adopted by this Conference inter-alia contained recommendations for pre-requisites for application of science and technology to development, improvement of science education, relation of science policy to development-planning, priority areas, technology transfer, CASTASIA Model and targets for the total R&D expenditure and machinery for regional cooperation. The Conference recommended that Asian countries should aim at reaching a minimum level of total national expenditure on research and development at 1% of their GNP.

(i) World Plan of Action:
The UN Advisory Committee on the Application of Science and Technology to Development prepared the “World Plan of Action” in 1971, as the Committee’s principal contribution to the programme of action for the Second United Nations
Development Decade. This Plan of Action consists of priority-areas for research, application of existing knowledge, building up an indigenous scientific and technological capacity and proposals for a fund. Taken together, the World Plan of Action proposals and, within them, the high priority-areas indicated/recommended three targets for increasing input of financial resources for achievement of significant results, viz.

**Target-1:** that the developing countries should increase outlays on research and experimental development, and revise the provision of scientific and technical services to 1 per cent of GNP by the end of the decade;

**Target-II:** that developed countries should increase science and technology aid to developing countries, to the extent of 0.05 per cent of their GNP;

**Target-III:** that developed countries should devote 5 per cent of their non-military research and development outlays to the science and technology needs of the developing countries.

According to 1970 calculations, it was projected that $9.5 billion would be required to achieve these targets.

**Considering these targets:** the majority of developing countries still spend less than 0.2 per cent of the GNP on Research and Development and the developed countries have failed to follow Target-II and III. In fact, their aid-flow to expand the capability of developing countries to apply science and technology for development has (in real terms) diminished. Also the projections for development/utilization of manpower in the S&T sector have not been achieved, by the majority of Third World Countries. The recommendation is reproduced below:
Growing Need for S & T Policy in Third World Countries

The UN World Plan of Action Recommendation:

<table>
<thead>
<tr>
<th>Per Capita GNP</th>
<th>Scientists/Engineers</th>
<th>High Level Manpower</th>
</tr>
</thead>
<tbody>
<tr>
<td>$200-500(350±50)</td>
<td>3,000/million population</td>
<td>300 per million population</td>
</tr>
<tr>
<td>$500-900(700±200)</td>
<td>6,000/million population</td>
<td>600 per million population</td>
</tr>
<tr>
<td>$900-2,000(1450±550)</td>
<td>12,000/million population</td>
<td>1,200 per million population</td>
</tr>
</tbody>
</table>

(ii) UN Conference on Science & Technology for Development (Vienna, 1979)
The United Nations organized a 2-week conference on Science and Technology for Development in Vienna in 1979, where some 4,000 delegates debated on 4 main topics: (1) the role of Science and Technology in Development, (2) institutional arrangements, (3) utilization of the existing UN System, and (4) science and technology and the future. The conference ended with the recommendations, firstly, for establishment of Inter-Governmental Committee on Science and Technology for Development, to oversee the implementation of the Vienna Programme of Action, and secondly, that a long-term financing system should be set up to finance activities aimed at strengthening the endogenous S&T capacities of the developing countries.

The global R&D expenditure was $96.4 billion in 1973. The striking disparity between rich and poor countries in levels of expenditure on R&D is even more marked when outlays are expressed in per capita terms. In 1980, the United States and several other European countries spent about $200 per capita; in contrast, most Latin American countries spent less than $5 per person, and the poorest countries of Africa and Asia spent less than $1 per capita!

The UN Conference on Science and Technology for Development, held in Vienna, adopted a Programme of Action which included, inter-alia, that a long-term financing system should be set up to finance a broad range of activities
aimed at strengthening the indigenous scientific and technological capacity of developing countries. Pending the establishment of such long-term financing arrangements, the Conference recommended setting up a voluntary Interim Fund, with a target not less than $ 250 million for 1980-81. The developed countries were in no mood to fulfill their obligations for implementing the recommendations of the Vienna Programme of Action. In the initial stage, IGCSTD met regularly and the Interim Fund was established to fund the S&T projects. But later, not much progress was made. For instance, out of 800 projects submitted for financial assistance, only 10 projects were approved in the first phase.

The major concrete outcome of the conference was the increased awareness among policy makers, planners and the general public about the pivotal role that S&T can play in the process of development and improving socio-economic conditions of the developing countries.

(iii) Castasia-II

The Second UNESCO Conference of Ministers, responsible for the Application of Science and Technology to Development and those responsible for Economic Planning in Asia and the Pacific (CASTASIA-II), was held in Manila in March 1982; similar conferences were held in other regions as well, with the objective to review

a- S&T in Asia and the Pacific,
b- major S&T policy issues involved in build-up of S&T capacity,
c- S&T for development and prospects of international and regional cooperation in S&T.

This resulted in the Manila Declaration, which emphasized the need for increase in the application of science and technology as tools for the welfare of their societies, to eradicate mass-poverty and endemic diseases, to provide productive employment and educate hundreds and millions of people and to create prosperity which can be shared by all.
3. SCENARIO FROM 1985 ONWARDS

Third World Poverty

(i) Present Position of the Third World:

Prof. Abdus Salam said in 1988: “What distinguishes one type of human from the other is the ambition, the power, the élan which basically stems from their differing mastery and utilization of present-day Science and Technology. It is a political decision on the part of those (principally from the South) who decide on the destiny of developing humanity if they will take steps to let Les Miserable (the “mustazeffin”) create, master, and utilize modern Science and Technology. The most severe problem facing the world today is the continuing poverty of the Third World and the increasing economic, social and knowledge-gap between the developed countries and the Third World. This single overwhelming fact will be the source of tremendous tensions and conflicts in the 21st century.” This position still remains substantially unchanged, as we go through the first decade of the 21st century.

Here are some stark statistics taken from recent UNDP Human Development reports up to 2001. Figures pertaining to UNDP Human Resource Development 2004 are given later. The UNDP report ranks the countries by measuring life expectancy, literacy rate, school enrolment and average income. For instance, Pakistan ranked 144th among 177 countries carried in the report.

- The average African household today consumes 20% less than it did 25 years ago.
- In 70 countries, with nearly a billion people, consumption is lower than it was 25 years ago.
- In about 100 countries, incomes today are less than they were a decade or more ago.
- More than 1 billion people are deprived of basic consumption needs.
- Of the 4.6 billion people living in developing countries, nearly three fifths lack basic sanitation. About a billion people have no access to clean water. A quarter do not have access to adequate housing. A fifth have no access to modern health-services. A fifth of the children do not attend school up to
grade 5. About a fifth do not have enough dietary energy and protein. Worldwide, 2 billion people are anaemic.

- Some 840 million people go hungry or face food-insecurity.
- 160 million children are moderately or severely malnourished.
- Nearly a billion (850 million) people are illiterate. Some 325 million children are out of school.
- Half a million women die each year in childbirth – at rates 10 to 100 times those in the industrialized countries.
- 11 million children under the age of 5 die each year from preventable causes, equivalent to 30,000 a day.
- Nearly a third of the people in the least developed countries – most of which are in Sub-Saharan Africa – are not expected to survive to age 40.
- About 1.2 billion people live on incomes of less than $1 a day; 2.8 billion on less than $2 a day.

On the other hand, we have rapidly growing disparity and inequality between the rich and the poor (see Fig 1.1):

- 20% of the world’s people in the highest income countries accounted for 86% of the $21.7 trillion total global consumption expenditures in 1995, the poorest 20% a minuscule of 1.3%.
- In 1993, the poorest 10% of the world’s people had only 1.6% of the income of the richest 10%.
Growing Need for S & T Policy in Third World Countries

![World Population Graph](image)

*Figure 1.1 (Cylinder graph)*

*Source: UNISEF (1999)*

<table>
<thead>
<tr>
<th>Table 1.1 Some Common Conditions in the Developing Countries</th>
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<tbody>
<tr>
<td>Total Population on Earth</td>
</tr>
<tr>
<td>Population in developing countries</td>
</tr>
<tr>
<td>Population living on less than $2 a day</td>
</tr>
<tr>
<td>Population living on less than $1 a day</td>
</tr>
<tr>
<td>Population having no access to clean water</td>
</tr>
<tr>
<td>People still waiting to benefit from the power of the industrial revolution</td>
</tr>
</tbody>
</table>

The terms of trade for the LDCs have declined a cumulative 50% over the past 25 years. For developing countries, as a group, the cumulative terms-of-trade losses amounted to $290 billion between 1980 and 1991.

The loss to developing countries from unequal access to trade, labour and finance was estimated by the Human Development Report of 1992 at $500 billion a year, ten times what they receive annually in foreign assistance. Arguments that the benefits will necessarily trickle down to the poorest countries seem far-fetched.
Table 1.2: Eliminating Poverty:  
massive deprivation remains, 2000 (Millions)

<table>
<thead>
<tr>
<th>Region</th>
<th>Living on less than $1 (PPP US$) a day</th>
<th>Total population under-nourished</th>
<th>Primary-age children not in School</th>
<th>Primary-age girls not in school</th>
<th>Children under age five dying each year</th>
<th>People without access to improved water sources</th>
</tr>
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<tbody>
<tr>
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<td>59</td>
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</table>

a. 1998-2000  
The HDI measures the average progress of a country in human development. Progress in human development was impressive during the 20th century, but massive human deprivation remains. According to UNDP 2004 Report, more than 825 million people suffer from under-nourishment (Table 1.2), more than 60 percent in Asia and the Pacific. Some 100 million children who should be in school are not, 60 million of them girls, over 75 percent concentrated on Sub-Saharan Africa (44M) and South Asia (32M). Over 10 million children under age five dying each year, 5 million in Sub-saharan Africa and 4 million in South Asia. Over one billion people do not have access to improved water sources, out of these, 950 million in South Asia and the Pacific and Sub-Saharan Africa do not get quality drinking-water. The position of improved sanitation is still worse. More than a billion people survive on less than $1 a day, again over 95 per cent live in the aforesaid mentioned regions. Currently 36 countries are counted in the low human-development category, the human development index ranging from 0.497 to 0.273. Some of these countries are: Pakistan (HDI 0.497), Nigeria (0.466), Senegal (0.437), Chad (0.379), and Sierra Leone (0.273).

Recognizing these problems, the world leaders of 189 countries at the United Nations Millennium Summit in September 2000 decided to set 8 key-objectives to end world-poverty.

i) Eradicate extreme poverty and hunger  
ii) Achieve universal primary education  
iii) Promote gender equality and empower women  
iv) Reduce child mortality  
v) Improve mankind’s health  
vi) Combat HIV/AIDS, malaria and other diseases  
vii) Ensure environmental sustainability  
viii) Develop a global partnership for development.

Little progress has been made so far in this direction.

Faheem Hussain concluded that the trends are for the worse. In spite of what the apologists of the new religion of globalization and neo-liberalism tell us, in the last few years, the condition of the poorest countries has worsened. The greatest benefits of globalization have been garnered by the fortunate and powerful few. The rest are sinking; they truly are the marginalized and the miserables of the earth. The Uruguay Round of GATT hardly changed the picture. Developing
countries, with three-quarters of the world’s people, will get only a quarter to a third of the income gains generated – hardly an equitable distribution – and most of that will go to a few powerful exporters in Asia and Latin America. The Uruguay Round and the recent WTO meeting in Doha left intact most of the protection for industry and agriculture in industrial countries, while ignoring issues of vital concern to poor countries – notably the problems of debt and the management of primary commodity markets. And they still have the nerve to call this highly biased system as “free trade” and “market democracy”. Despite a reduction in the relative differences between some countries, absolute gaps in per capita income again have increased. Even for East Asia and the Pacific, the fastest growing region, the absolute difference in income with high income OECD countries has widened from about $6000 in 1960 to $13,000 in 1998. (See figure 1.2)

(ii) Demand and Supply and Linkages:
Najamabadi and Lall (1995) argue that the greatest problem with the science and technology infrastructure has been its lack of effective linkages with the productive sector. Dogson (1997) also emphasized that few intermediary institutions in East Asia have been able to harness them to raise productive efficiency in industrial enterprises.

Figure 1.2
In reviewing the previous researches on innovation policy, most of the results stress that the linkages between supply of, and demand for, technology, rather than demand or supply itself, would be the weakest point for the LDCs i.e. the Third World.

The demand for technology is a function of a nation’s level of technological capability, government R&D expenditure, and some other market-factors; the supply solely depends on the nation’s investment-capability. Therefore, at the beginning & early stage of industrial development, demand for technology remains at a lower level than supply. Sun G. Kim (2000), proposed that an effective innovation-policy for the less developed countries might be different from that of the advanced one and he analyzed the situation in the following way:

![Figure 1.3. Conceptual time-gap between demand and supply of technology](image)

*Note:* Without any theoretical background, the curves are drawn sigmoid, as shown in an empirical study of Korea.

First, some key-terms used in the analysis are defined. For the sake of simplicity, demand for technology is considered to be all activities by firms acquiring new knowledge, know-how, or plant for their production-processes. It includes any type of firm’s effort to upgrade its technological level by purchasing technology or advanced machines, contracting licenses, training workers, inviting consultants, and so on. Supply of technology can be defined as all activities
generating or providing technology or any technology or any technological resources, such as manpower, facilities, and information, that will be demanded by producers.

Let us compare the pattern of supply and demand between advanced and developing countries. In general, in advanced countries, development of industrial technology is delegated to the private sector, while the government is more concerned with projects involving large capital-outlay or processing large economic externalities. In contrast, in developing countries, where the scientific and technological level remains at the initial stage, governments usually take a leading role in all areas of development.

Figure 1.3 shows the conceptual time-gap between demand and supply of technology, which can be applied at the early development stage in LDCS. Suppose an economy maintains its traditional way of production and consumption. The economy’s total quantity of technology supplied and demanded is negligible until time T₁ in the figure.

If the government initiates investment of the national resources from time T₁, its capability will be increased as in schedule S(T), which shows the nation’s supply of technology as investment increases. This does not, however, generate any demand from firms until a certain level is reached by time T₂. At T₂ some demand is generated from firms, provided that their market circumstances are satisfied. It therefore could be interpreted that many LDCs, which have difficulty in activating indigenous demand for technology from their private sector, still remain at levels between time T₁ and time T₂.

The main factors related to the effectiveness of innovation-policies are:

- national goal of industrial development;
- price mechanism;
- degree of competition;
- market size;
- risk factors;
- stage of industrialization;
- type of technology-development task.
Of these, the price mechanism of the market is the most critical. If this does not work efficiently, firms rarely have any motivation for cost-reduction or product differentiation through R&D investment. If non-price competition prevails in any economy, it is necessary for the government to establish well-functioning price-systems before introducing the direct tools of support for private R&D. That is, governments need to promote flow of market-information and to guarantee fair competition by anti-trust regulations.

The degree and type of market competition should also be considered. For a monopolistic market in a developing economy, direct support, rather than indirect policies would be more efficient. Direct support reduces the distortion of resource-allocation caused by a monopoly situation, because direct support of price or cost shifts marginal-cost curves outward, pushing prices down and increasing output. However, monopolistic competition generally reduces R&D incentives for potential entrants. This is the reason why the reorganization of the market should be targeted to establish a more competitive market, rather than a monopolistic one.

Risk factor is another important issue that policy-makers need to consider. The effectiveness of a policy will be affected by the degrees of risk perceived by the public. If markets for goods and raw materials become volatile, as a result of demand or supply shocks, the government should place top priority on reducing risk in R&D activities through any indirect means of support.

4. NEED FOR S&T POLICY IN THIRD-WORLD COUNTRIES

Accordingly, there is a greater realization, more now than in the past, that each country should develop its own National Science and Technology Policy for socio-economic development, and also to ensure the mechanisms for its periodical review, so as to synchronize with the socio-economic development plans. The following factors are responsible for this approach:

1. Science as a positive force in the process of socio-economic development is only possible if there is a critical national capacity for science, together with a capability for utilization of technology.

2. Change in attitude from importation of turn-key technology to that of innovative re-engineering and local development of technology, in cooperation with International Corporations/Institutions and UN organizations.
3. Technology management is enshrined in mechanisms for commercialization of research – financing for pilot-plants, laws and regulations, intellectual property rights, venture capital, business incubators / clusters.

4. Establishment of an enhanced science-based advisory system, to facilitate informed policy-decisions.

5. Application of advanced technologies in public and corporate governance.

6. New knowledge is generated and new technologies can be developed and commercialized at a rapid pace, through the growth in endogenous R&D and innovative processes.

7. In traditional sectors, there is increasing application of advanced technologies (new materials, biotechnology, nanotechnology etc).

**Basics of Science and Technology Policy for the Third World**

A nation cannot rise up and overtake or catch up with advanced nations, in all aspects of life, until it takes maximum benefit from science and technology.

**Benefits of Science & Technology:** Scientific knowledge has yielded technological applications that have been of great benefit to humankind. Some of these benefits are mentioned below:

- health-care has improved dramatically
- life-expectancy has strikingly increased
- infant-mortality has decreased
- more rapid means of communication are available
- agricultural output has increased.
- technological developments have provided luxuries to humankind
- exploitation of energy-resources has helped the advancement of S&T manifold
- rapid economic development and self-reliance;
- improved living status of a society

The applications of science and technology in the developing countries still suffer drawbacks, particularly lack of awareness of its role in enhancing industrial development, which is reflected in low involvement and expenditure of the private sector in research and development. The general system of S&T
research activities in developing countries is characterized by weakness of coordination, and dispersal without common linkages, rather than being concentrated in key-areas with efforts towards developing synergies. This dispersion and disconnection often results in unjustified duplication and wastage of the meager resources allocated for research.

Developing an effective policy for science and technology is the first step that could provide the basis, the proper context and the direction to all S&T activities of a developing nation. It has been seen that countries whose policy-framework is strong are better able to achieve practical and significant results through their science and technology efforts. The following are some of the features that are considered desirable in a science and technology policy; it should:

- Contribute to and help ensure national security.
- Contribute to bringing about economic and social development, starting at the grassroots level.
- Bring together all sectors of the society, industrialists, decision-makers, implementers or beneficiaries, towards science and technology as a prime tool for development.
- Maximize scientific and technological capacities, and support interaction between S&T systems and production-systems, so as to enhance economic strength.
- Give due attention to enhance the capabilities of science and technology research-centers and institutions, by raising and allocating the needed funds, internal and external training, equipping the laboratories and enriching libraries and documentation centers.
- Encourage scientific publishing and dissemination of information, audiovisual scientific programmes and community enlightenment in the field of science and technology.
- Give due attention to novel technologies, viz biotechnology, information and communication, space sciences, renewable energies and computer sciences, so as to discover and exploit the natural resources of the country with special attention on health, food-security, energy and mineral resources; also encourage creativity and discoveries.
- Curb emigration of experts and the workforce, by adopting adequate measures that motivate and create a conducive environment to encourage reversal of the emigration trend.
• Encourage cooperation amongst experts from developing countries, as well as liaison with experts from advanced countries.
• Create appropriate environmental, legal and legislative conditions, conducive to ethical practices and protection of science and technology advancements, so as to prevent misuse.

The succeeding chapter would discuss some of the present challenges and issues faced in developing an S&T Policy.
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5. The Vienna Programme of Action on Science and Technology for Development, UN Conference on Science and Technology for Development, Vienna, pp.36, 1979
9. Abdus Salam, Notes on Science, Technology and Science Education in the Development of the South. Fourth Meeting of the South Commission, Kuwait, pages 122, 10-12 December 1988
1. INTRODUCTION

Third-world countries lack basic amenities of life, in general and face various challenges and issues in the development of science and technology leading to socio-economic development. Some of these are listed here:

- Population explosion
- Illiteracy
- Lack of indigenous research
- Lack of appropriate Human Resources
- Lack of R&D infrastructure
- Brain Drain
- Lack of integration among Industry, Academia and Research Institutions
- Lack of Science Policy and Action Plan
- Isolation from Regional and International Network of S&T
- Lack of Government commitment to S&T development

One third of the population (about 2 billion people) are living below poverty-line and could not have basic amenities of life. The above factors lead to widen the gap between developed and under-developing nations.
2. THE OVERALL SITUATION IN THIRD-WORLD COUNTRIES

The UNDP Human Development Report 1997 has been compiled on the topic “Human Development to Eradicate Poverty”. With this specialized theme, it recognizes the following situation in the third-world countries:

a- Accelerating the reduction in human poverty, rapid improvements in human capabilities and economic growth can be mutually reinforcing. When a good share of the resources generated by economic growth are channeled into human development, and when the pattern of economic growth generates a demand for increasing skills, a virtual spiral of growth and human development, of reduction in income-poverty and human poverty results. As the Human Development Report of 1996 showed, 3 Asian countries, Indonesia, the Republic of Korea and Malaysia, all followed this model. Countries that invested relatively less in human development, such as Egypt and Pakistan, are now left with a large backlog of human poverty.

b- “The Third World countries are just not serious about science and technology, or about their own economic and social development!” Once again, we have to request the governments of the South that they must increase science-budgets significantly. They must allocate at least 2% of their budgets to scientific research, if it is to have any meaningful impact.

As the late Prof. A. Salam said, “We in the Third World are just not serious about Science and Technology”. He noted that in 1980 the industrialized countries spent between 2 and 2.5% of their GDP on Research and Development, whereas this ratio was less than 0.3% for most developing countries, i.e. too low by a factor of 10. Unfortunately, the situation has not greatly improved in the last twenty-eight years, as can be seen from Table 2.2.

Table 2.1 compares the relative world-share of expenditure on research and development by the various major regions of the world in 1990, 1994 and 2005.
Table 2.1: Expenditure on Research and Development as a percentage of world share

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<th>1994</th>
<th>2005</th>
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<td>India and Central Asia</td>
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Source: UNESCO Science Report 2005, Table 1 (Page 4)

Table 2.2: Estimated Expenditure on Research and Development as percentage of GDP in 1980, 1997 & 2005

<table>
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<th></th>
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The 1980 figures are from Prof. Salam’s paper cited earlier, whereas the recent figures are from the UNESCO World Science Report 2005 and the UNDP Human Development Report (2007 / 2008).

As these figures (Table 2.1) show, more than four/fifths of the global scientific research and technological development effort is currently made by the developed countries of the West and Japan. This is characteristic of a highly non-egalitarian situation, even more so than the gross domestic product (GDP) distribution. The share of the global GDP for the OECD countries plus the NICs is 56%. This is also reflected in the damning fact that, although the Arab countries’ share in global R&D expenditure is barely 0.2%, their share of global GDP is 3.3%. The low level of scientific effort is also reflected in the number of scientists and technologists working in Third-World countries. “Logically, most of the world’s scientists are where the science happens; the developing countries average only 300 scientists and engineers per million people, as against, 3,300 per million in the industrialized nations”.

Let us compare figures of developing countries (Table 2.1) with those of the developed countries. In 1994, North America (2.5%), Japan and the newly industrialized countries (NIC) (2.3%) have the highest indices, followed by Western Europe (1.8%) and Oceania (East Asia and Pacific) (1.3%). The average for OECD countries is 2.4%. The CIS and both Central and Eastern Europe (CEE) fall in the vicinity of a 1% ratio, down from 3.4% for the former USSR in 1990 and 1.7% for the CEE in 1990.

As seen from Table 2.2, many of the developing countries are still spending less than 0.4% of their GDP on research and development. Amongst the developing countries, only Singapore (2.3%) and Republic of Korea (2.6%) spend a substantial part of their GDP on R&D, while China (0.6%), India (0.8%), Brazil (1%), Iran (0.7%), Turkey (0.7%), South Africa (0.8%), Chile (0.6%), Peru (0.1%), Venezuela (0.3%) occupy an intermediate position, with most of the other developing countries spending less than 0.4% of the GDP on R&D. The world average is 2.2%. In recent years more funds are allocated for the S&T sector but further more is required. These figures reflect the fact that the developed countries spend proportionately much more of their very large GDPs on science than do the developing countries out of their already very small GDPs.
As one can see, the situation in the Third-World countries is generally disappointing. Apart from a rapid increase in the case of NICs, the ratio for the rest of the developing countries is as it was twenty-eight years ago! The promises made over the years have not been kept. Also the problem is not just one of expenditure, but also how this is distributed. For example, in Pakistan and India, a large portion of the scientific budget is put into defence and nuclear reactors and bombs. As Prof. C.N.R. Rao puts it:

"Of a total scientific investment of Rs.40 billion ($950m) in science, barely $2 billion is spent for basic research in physics, chemistry, biology and engineering, on which industry depends. The remaining Rs.38 billion is channelled into defence projects and nuclear reactors."

Another aspect of scientific development is the expenditure on education and how it compares with military spending. In Table 2.3, we compare the educational and military expenditure of key Third-World countries. The general trend of a developing country is that total educational expenditure as percentage of GDP seems to be rising gradually while Defence expenditure as percentage of national GDP seems to be reducing over time. In industrialized countries, total educational expenditure as percentage of GDP is 6% compared to Defence expenditure as percentage of GDP being only 2% (3 times higher!!).
Table 2.3: Comparative educational and military expenditures of selected Third World countries (2005)

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<tr>
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<th>Defense expenditure as % of GDP</th>
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</tr>
<tr>
<td>Egypt</td>
<td>--</td>
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</tr>
<tr>
<td>South Africa</td>
<td>5.3</td>
<td>18.5</td>
</tr>
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<td>Sub-Saharan Africa</td>
<td>4.1</td>
<td>18.1</td>
</tr>
<tr>
<td>Africa</td>
<td>1.6</td>
<td>6.1</td>
</tr>
<tr>
<td>All developing countries</td>
<td>3.3</td>
<td>6.4</td>
</tr>
<tr>
<td>LDCs</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Industrialized countries</td>
<td>6.0</td>
<td>12.8</td>
</tr>
<tr>
<td>World</td>
<td><strong>4.9</strong></td>
<td><strong>15.7</strong></td>
</tr>
</tbody>
</table>

3. Some Key-Components for Development

(i) Firstly, the foundations of the development process must be laid on a high level of literacy and quality-education, at all levels. There are tens of thousands of students who have an IQ in the near-genius category, but to unleash their creativity they should be exposed to a challenging educational environment, which would teach them to think and find novel solutions to difficult problems. At present, they are trained mostly to memorize and reproduce facts in examinations, often without grasping the fundamental underlying principles and their applications in real-life situations. For this, a community of good teachers and researchers is essential. If we can attract our brightest graduates to take up academic and research careers, through the introduction of an attractive salary-structure and facilities; this would be a major step forward in the right direction.

(ii) The second important facet of development is to upgrade the universities and research-centers to an international level of excellence through development and retention of world-class researchers and provision of appropriate research-facilities. They should be the focal points for creation of new knowledge. When we have high-quality basic research in various fields and we can work at the cutting edge of knowledge, only then we will have the capacity to absorb new and emerging frontier-technologies and adapt them for our use. It must be understood that basic and applied research go hand-in-hand, being two sides of the same coin, and one must not be ignored at the cost of the other.

(iii) The third important facet of the developmental process is concerned with the application of research and technology for industrial development. This is a complex issue, involving interactions between technologists and economists in order to optimize the production-process on a reasonably large scale, so that the financial feasibility could be properly worked out and the processes sold to investors. This is a stage where science in the Third-World countries has failed. The few products and processes that are developed cannot be marketed because there has been inadequate effort and financial support for development of each process at the pilot-plant level, and hardly any research is carried out in the industries.
The fourth facet of development involves the introduction of suitable governmental policies and mechanisms to encourage investment by entrepreneurs in indigenously developed products and processes. These include, tax-incentives, provision of risk-capital by access to venture-capital funds, protection of intellectual-property rights, rationalization of import-duty structure, banning of smuggling to protect local industry, and creation of “investor confidence” through stable and long-term government policies.

The most important, fifth factor for success is the introduction of a merit-based system at all levels, so that the most creative people can be inducted and encouraged – in other words, the operation of a system in which only the brightest are encouraged to go up the ladder, and suitable reward/punishment mechanisms are incorporated as an integral component of a highly transparent but demanding accountability system. Parallel outlets for the second best would also need to be worked out.

The key to success in any developmental programme lies unquestionably in the quality of manpower (Table 2.4) executing it. Science and Technology cannot prosper and prove economically beneficial unless the brightest young men and women are inducted into the S&T effort. At present, this is not the case. The best students in the Third-World countries opt for medicine or business-oriented disciplines and the career-structures and facilities in our universities and S&T organizations are such that, generally, the academically weaker candidates opt for teaching and research professions, thereby perpetuating mediocrity. As a result, universities and research organizations have suffered and are frequently comparable only to low-level colleges in the West. Financial inputs alone cannot change this dismal situation. The career-structures need to be appropriately fashioned and a stimulating research environment created, in order to attract intelligent and creative students to opt for research-careers in various scientific fields.
### TABLE 2.4 Data on R&D Expenditure and Manpower, as re-arranged in order of Expenditure (2005 - 2006)

<table>
<thead>
<tr>
<th>Countries</th>
<th>Table (a)</th>
<th>Table (b)</th>
<th>Higher Education (%) of total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R&amp;D Exp. in Productive (% of total)</td>
<td>R&amp;D Exp. in General Services (% of total)</td>
<td>R&amp;D Exp. in Productive (% of total)</td>
</tr>
<tr>
<td>1 India</td>
<td>95.1</td>
<td>19.8</td>
<td>93.06</td>
</tr>
<tr>
<td>2 Bulgaria</td>
<td>89.6</td>
<td>25.5</td>
<td>77.92</td>
</tr>
<tr>
<td>3 Korea</td>
<td>88.9</td>
<td>77.3</td>
<td>73.04</td>
</tr>
<tr>
<td>4 Philippines</td>
<td>87.1</td>
<td>68</td>
<td>--</td>
</tr>
<tr>
<td>5 Japan</td>
<td>85.5</td>
<td>77.4</td>
<td>72.97</td>
</tr>
<tr>
<td>6 Czech Republic (Czechoslovakia)</td>
<td>83.7</td>
<td>66.2</td>
<td>72.91</td>
</tr>
<tr>
<td>7 Germany (FR)</td>
<td>83.5</td>
<td>69.6</td>
<td>79.38</td>
</tr>
<tr>
<td>8 U.S.A</td>
<td>81.4</td>
<td>70.3</td>
<td>--</td>
</tr>
<tr>
<td>9 France</td>
<td>80.6</td>
<td>63.4</td>
<td>70.6</td>
</tr>
<tr>
<td>10 Singapore</td>
<td>76.1</td>
<td>65.7</td>
<td>66.37</td>
</tr>
<tr>
<td>11 Switzerland</td>
<td>74.8</td>
<td>73.7</td>
<td>64.87</td>
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<tr>
<td>12 Denmark</td>
<td>73.3</td>
<td>66.6</td>
<td>72.1</td>
</tr>
<tr>
<td>13 Austria</td>
<td>72.8</td>
<td>67.7</td>
<td>72.7</td>
</tr>
<tr>
<td>14 Spain</td>
<td>72.2</td>
<td>55.5</td>
<td>62.15</td>
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<td>15 U.K.</td>
<td>71.7</td>
<td>61.7</td>
<td>50.67</td>
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<tr>
<td>16 Mexico</td>
<td>71.6</td>
<td>49.5</td>
<td>70.34</td>
</tr>
<tr>
<td>17 Australia</td>
<td>70.1</td>
<td>54.1</td>
<td>48.59</td>
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<td>18 Italy</td>
<td>67.7</td>
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<tr>
<td>19 Netherlands</td>
<td>67.5</td>
<td>57.6</td>
<td>68.2</td>
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<tr>
<td>20 Canada</td>
<td>61.2</td>
<td>52.4</td>
<td>71.81</td>
</tr>
<tr>
<td>21 Peru</td>
<td>54.8</td>
<td>29.2</td>
<td>--</td>
</tr>
<tr>
<td>22 Turkey</td>
<td>48.7</td>
<td>37</td>
<td>50.93</td>
</tr>
<tr>
<td>23 Central African Rep.</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>24 Jordan</td>
<td>--</td>
<td>--</td>
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</tr>
<tr>
<td>25 Kuwait</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>26 New Caledonia</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>27 Yugoslavia</td>
<td>--</td>
<td>--</td>
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</tr>
</tbody>
</table>

4. THE BRAIN DRAIN

Another crucial aspect of the critical situation of science and education in developing countries is the “brain-drain” (Table 2.5) from these countries. The causes of the “brain-drain” are many: the lack of academic and research environment, the lack of facilities, the lack of professional fulfillment, low salaries, the attraction for the high standard of living in the developed countries, wars and civil wars, etc. Quantitative data are hard to come by. However there is a recent study, which attempts to quantify this phenomenon. They estimate that for Iran the fraction of the population with tertiary education living in the OECD countries is between 25 and 34 percent, while for Korea it is between 15 and 17 percent: in the Philippines it is between 9 and 10 percent. In Sri Lanka this fraction is between 24 and 31 percent and in Pakistan it is a little over 7 percent, while in India it is around 2.7 percent. However, these figures do not take into account the sizeable flow of professionals from the Indian sub-continent to the Gulf States and, therefore, underestimate the brain-drain. In some African and Latin American countries, the migration rates are dramatic. In Ghana the migration-rate of highly educated individuals is between 26 and 35 percent. In the case of Algeria, Gambia, Senegal, Tunisia, Jamaica, Trinidad and Tobago and Guyana, more people with tertiary education live abroad than in the country of origin.

The estimates show that there is an overall tendency for migration rates to be higher for higher skill-levels, suggesting that migrants are generally better educated than the average population. With the exception of Central American countries, the highest migration-rates in the countries in our sample are for individuals with tertiary education. In a number of countries, especially small countries in the Caribbean, Central America and Africa, this skill-group experiences losses to migration that reach above 30 percent. These are indeed dramatic figures and show how severe is the drain of educated people from the developing countries to the developed countries (we find a substantial brain drain also in some larger Asian countries, such as Iran, Korea, Taiwan (Province of China), and the Philippines). These numbers suggest that the outflow of highly skilled individuals from LDCs is a phenomenon that cannot be ignored by policy-makers.

Thus, not only do the developing countries contribute to the wellbeing and riches of the industrialized countries through the massive outflows of capital, in terms of interest-payments on debt and the effects of the deteriorating terms-of-trade, but also
they contribute their best and brightest brain for the further advancement of these already very rich countries. It would be interesting to determine, for example, how many scientists and technologists of Asian (particularly Indian and Chinese) origin have contributed to the growth of the high-tech industries in the United States.

Table 2.5: Migration-Rates to OECD Countries, by Educational Attainment, for Selected Developing Countries, 1990

<table>
<thead>
<tr>
<th>Country of Origin</th>
<th>Total</th>
<th>Primary or Less</th>
<th>Secondary</th>
<th>Tertiary</th>
<th>U.S. As a Percentage of Total OECD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia and Pacific</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>0.1</td>
<td>-</td>
<td>0.2-0.2</td>
<td>2.5-2.6</td>
<td>25.9</td>
</tr>
<tr>
<td>China</td>
<td>0.1</td>
<td>-</td>
<td>0.2-0.2</td>
<td>3.0-3.1</td>
<td>51.5</td>
</tr>
<tr>
<td>India</td>
<td>0.2</td>
<td>-</td>
<td>0.3-0.3</td>
<td>2.6-2.7</td>
<td>44.1</td>
</tr>
<tr>
<td>Iran</td>
<td>1.5</td>
<td>-</td>
<td>2.0-2.1</td>
<td>25.6-34.4</td>
<td>51.3</td>
</tr>
<tr>
<td>Korea</td>
<td>4.2</td>
<td>0.5</td>
<td>3.3-3.4</td>
<td>14.9-17.6</td>
<td>36.0</td>
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<td>1.2</td>
<td>-</td>
<td>1.2-1.2</td>
<td>22.7-29.4</td>
<td>18.2</td>
</tr>
<tr>
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<td>-</td>
<td>0.5-0.5</td>
<td>6.9-7.4</td>
<td>35.2</td>
</tr>
<tr>
<td>Philippines</td>
<td>3.1</td>
<td>0.1</td>
<td>6.0-6.4</td>
<td>9.0-9.9</td>
<td>71.6</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>0.8</td>
<td>-</td>
<td>0.5-0.5</td>
<td>23.6-31.0</td>
<td>14.1</td>
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<td>0.1</td>
<td>2.3-2.3</td>
<td>3.0-3.1</td>
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<td>0.1</td>
<td>0.8-0.8</td>
<td>8.4-9.2</td>
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<td>46.2-86.0</td>
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<td></td>
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<td>19.7-24.6</td>
<td>55.0-122.1</td>
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<td>Cameroon</td>
<td>-</td>
<td>-</td>
<td>0.1-0.1</td>
<td>3.2-3.4</td>
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</tr>
<tr>
<td>Central African Republic</td>
<td>-</td>
<td>-</td>
<td>0.1-0.1</td>
<td>1.7-1.8</td>
<td>100.0</td>
</tr>
<tr>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>0.5-0.6</td>
<td>100.0</td>
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<tr>
<td>Egypt</td>
<td>0.5</td>
<td>-</td>
<td>0.8-0.8</td>
<td>5.0-5.3</td>
<td>50.6</td>
</tr>
<tr>
<td>Gambia</td>
<td>0.2</td>
<td>-</td>
<td>0.6-0.6</td>
<td>61.4-159.3</td>
<td>100.0</td>
</tr>
<tr>
<td>Ghana</td>
<td>0.4</td>
<td>-</td>
<td>0.7-0.7</td>
<td>25.7-34.6</td>
<td>53.3</td>
</tr>
<tr>
<td>Malawi</td>
<td>-</td>
<td>-</td>
<td>0.1-0.1</td>
<td>2.0-2.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Mali</td>
<td>-</td>
<td>-</td>
<td>0.1-0.1</td>
<td>0.9-0.9</td>
<td>100.0</td>
</tr>
<tr>
<td>Mauritius</td>
<td>0.2</td>
<td>-</td>
<td>0.1-0.1</td>
<td>2.0-2.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Mozambique</td>
<td>-</td>
<td>-</td>
<td>0.5-0.5</td>
<td>8.6-9.4</td>
<td>100.0</td>
</tr>
<tr>
<td>Rwanda</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2.2-2.3</td>
<td>100.0</td>
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<tr>
<td>Senegal</td>
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<td>-</td>
<td>14.5-17.0</td>
<td>47.7-91.3</td>
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</tr>
<tr>
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<td>24.3-32.1</td>
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<td>-</td>
<td>0.4-0.4</td>
<td>7.9-8.5</td>
<td>32.4</td>
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<tr>
<td>Sudan</td>
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<td>-</td>
<td>0.1-0.1</td>
<td>1.8-1.8</td>
<td>100.0</td>
</tr>
<tr>
<td>Togo</td>
<td>-</td>
<td>-</td>
<td>...-01</td>
<td>1.3-1.4</td>
<td>100.0</td>
</tr>
<tr>
<td>Tunisia</td>
<td>8.6</td>
<td>0.2</td>
<td>20.2-25.3</td>
<td>63.3-172.2</td>
<td>1.1</td>
</tr>
</tbody>
</table>
Obstacles & Barriers for Development of Science & Technology in Third World

North America

<table>
<thead>
<tr>
<th>Country</th>
<th>Primary</th>
<th>Secondary</th>
<th>Tertiary</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>El Salvador</td>
<td>11.3</td>
<td>1.6-1.6</td>
<td>66.6-199.3</td>
<td>100.0</td>
</tr>
<tr>
<td>Jamaica</td>
<td>20.3</td>
<td>0.7-0.7</td>
<td>33.3-50.0</td>
<td>61.0</td>
</tr>
<tr>
<td>Mexico</td>
<td>7.7</td>
<td>1.6-1.7</td>
<td>20.9-26.4</td>
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</tr>
<tr>
<td>Panama</td>
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<td>0.3-0.3</td>
<td>16.0-18.9</td>
<td>100.0</td>
</tr>
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</table>

South America

<table>
<thead>
<tr>
<th>Country</th>
<th>Primary</th>
<th>Secondary</th>
<th>Tertiary</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>0.6</td>
<td>-</td>
<td>1.0-1.0</td>
<td>2.7-2.8</td>
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<td>-</td>
<td>1.6-1.6</td>
<td>1.4-1.4</td>
</tr>
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<td>-</td>
<td>1.9-1.9</td>
<td>6.0-6.4</td>
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<tr>
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<td>...-01</td>
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<td>23.7-31.1</td>
<td>77.5-345.3</td>
</tr>
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<td>Peru</td>
<td>1.0</td>
<td>-</td>
<td>2.7-2.7</td>
<td>3.4-3.6</td>
</tr>
<tr>
<td>Venezuela</td>
<td>0.4</td>
<td>-</td>
<td>0.8-0.8</td>
<td>2.1-2.2</td>
</tr>
</tbody>
</table>

Source: Hussain's calculations using data from the 1990 census, OECD's Continuous Reporting System on Migration, the United Nations Population Yearbook, and the Barro-Lee data-set on educational attainment. The upper bound of the range is calculated assuming that the Barro-Lee figures include migrants in the population, while the lower bound is calculated assuming that they do not. Primary education or less corresponds to reported years of schooling between 0 and 8, secondary education to years of schooling between 9 and 12, and tertiary to years of schooling above 12. Estimates assume that migrants to non-US OECD countries have the same average educational attainment as migrants to the United States. Migrants are defined as the stock of foreign-born population in Australia, Canada, and the United States. For all other OECD countries, migrants are the stock of foreign population in the country, (...) indicates less than 0.1 percent.

Because of the universality of science, it is relatively speaking easy for scientists to perform their scientific work in any country around the world, even if it is not their native land and the people do not speak their native language. As a result, there are substantial numbers of scientists who have “brain-drained” away from their native countries and work in countries around the world. In the case of scientists from Islamic countries, this migration is often to a non-Islamic country. In addition, there is also a significant amount of “internal brain-drain” within the Islamic world, mainly to the oil-rich Arab countries.

It is usually assumed that the only motive force in the brain-drain is money; that is, the salaries offered to scientists. This is a gross misperception of the situation. Whereas salaries do play a significant role in the brain drain, there are numerous examples of scientists choosing locales with lower salaries because of various other favourable factors pertaining to the performance of scientific work. One example is South Korea, which has succeeded, over the past two decades, to
reattract from abroad a number of senior scientists, even though the salaries offered were below those obtainable abroad.

**Among the factors important to a scientist in choosing the locale for his scientific work are:**

a. A favourable research-environment relative to the resources of the country. This includes opportunities for communication with other scientists and a minimum of bureaucratic red-tape in handling the logistic aspects of research.

b. Recognition of achievement on the part of decision-makers in the country and by the society of the country as a whole.

c. Salaries that are generous relative to the average salary-structure of that country.

There are also measures that can be taken during the time while the budding scientist is receiving advanced-level education abroad. The home scientific institutions should maintain contact with such students abroad and possibly offer them scientific employment/internship at home during long vacation periods. In addition, it is essential that such students, while abroad, receive some auxiliary education in those contextual aspects of R&D which are relevant to the needs in a developing country.

5. **DETERMINATION OF PRIORITIES IN S&T**

Priorities in science and technology have to be matched with the national development goals and the input of S&T policy in the socio-economic plan. The priority areas then have to be reviewed in the perspective of over-all balanced development in all the economic sectors. S&T priorities for each sector are further elaborated, which need immediate attention. Also one primary function of the S&T policy is to establish relative priorities for programmes, which generate new technologies.

The **UNESCO method** envisages research-techniques for consensus-formation and an analysis of national goals and scientific capabilities. The output of the method is a series of priority-charts and profiles showing the relative merits of science and technology for achievements of developmental objectives and relative dependence of development sectors and sub-sectors on S&T inputs. Even without taking this exercise in hand, it has been known for decades that the
basic problems of developing countries are food, disease, shelter, clothing, health-cover and optimal exploitation and utilization of natural resources. For instance, Pakistan despite having a well-established irrigation system, hundreds of qualified agriculture scientists working in various R&D institutes and millions of rupees expenditure on agriculture R&D, continues to import edible oil at the cost of millions of dollars every year. Drought or flood turns the food into a food-deficit. Recently, Pakistan had to import two million tons of wheat to meet the food requirement of the people. So, the priorities are there, but we are not able to resolve them, due to reasons of dearth of dynamic S&T managers, lack of coordination and effective multi-disciplinary approach.

Priorities in science and technology have to be determined primarily in accordance with the national developmental goals. However, the extent of R&D effort needed would be much greater in those specific fields where the specific scientific knowledge and technology is lacking. Furthermore, opportunities should also be available to the scientific community to undertake R&D in areas where it perceives possibilities for advancement of knowledge or evaluation of technologies which may soon lead to creation of new inventions/increase in productivity.

The S&T priorities have, of course, to be followed in the perspective of overall balanced development and, as a large section of population lives in thousands of villages, considerable attention must also be focused on the study and solution of rural problems. The broad determination of priority areas has to be translated into sectoral and institutional goals, S&T programmes, research projects, both long-term and short-term, by the concerned implementing agencies.

Role of Modern S&T: The tremendous advances made in the field of science and technology in the last few decades have transformed our lives in a multitude of ways. This is evident in almost every facet of human endeavor, including health, transportation, communication, agriculture and engineering. These advances have been driven by an ever-growing volume of exciting discoveries, largely emanating from the science laboratories in the West, and their transformation into new products or processes that have flooded world-markets, thereby showering vast economic rewards on those nations which have had the courage and vision to make science and technology the cornerstone of their respective development programs. It is imperative that Third-World countries invest massively in education, particularly in basic and applied sciences, in order to shrug off their continuous dependence on the West for meeting all their needs,
such as industrial machinery, pharmaceuticals, defence equipment, etc. This is only possible if we build world-class Centres of Excellence where new knowledge can be created and applied towards the development of new products and processes. We must realize that our real wealth is not the oil, minerals or other natural resources that we may possess, but our children. It is only through investing in them by incorporating a challenging educational system, which can unleash their creativity, and by providing them the opportunities of contributing to our national development in various fields of science and technology and industry that we can make genuine progress.

The developments in the field of information-technology have occurred at a mind-boggling pace. From only 3 million global internet users in 1994, the number has grown to over 300 million users now, with an 80% annual increase in the last two years alone. Some 1 billion web-pages can now be accessed through the web, with 3 million new pages being added each day! In the US, the benefits of IT to the economy have been remarkable. Real business-investment in IT equipment more than doubled between 1995 to 1999 (from US$ 243 to US$ 510 billion), with the software component increasing from US$ 82 billion to US$ 149 billion. Although IT capital contributes to only 6% of private business income in USA, it contributed to half or more of the acceleration in US productivity-growth in the second half of 1990s, and to nearly a third of the real economic growth. There are huge opportunities, which are opening up because many companies in USA and Europe are outsourcing operations to save costs – we must be prepared to benefit from such opportunities.

Another example is that of biotechnology. Just as the last century was regarded as the century of micro-electronics and computer science, the current century will probably be known for the startling progress in biochemical sciences. It will lead to dramatic changes in the quality of life, for example through the development of new pharmaceuticals, for tackling cancer, heart diseases, delaying the aging process and leading to fantastic increases in the yields of agricultural produce through genetic manipulation. Gene-based medicine and plant tissue-culture technology are just two of the many examples that would result in economic prosperity for countries which invest in this field.

Hydrogen fuel-cell technology promises to revolutionalize the transportation system, doing away with the ubiquitous presence of petroleum products. By using water as the source of hydrogen, produced by catalytic cleavage of the water molecules, energy can be produced by burning the hydrogen so produced. Nano-
technology is developing rapidly. The numerous applications in a variety of fields include new materials, electronic devices, surface engineering, cosmetics, nanotubes and many others. The market of nano-particles is around US$ 40 billion and is expanding dramatically. These and other such applications hold enormous potential for rapid economic development, but such technology-based development is mostly by-passing the Third World countries, and such opportunities are being lost.

6. IDENTIFYING TECHNOLOGICAL REQUIREMENTS FOR NATIONAL DEVELOPMENT

Ideally, the technological needs of economic sectors should be jointly assessed by all the stakeholders. There is a need to develop a strong linkage between industry and Research Institutes. Past experience shows that this has not occurred due to the following reasons:

(i) The involvement of private firms in the identification of sectoral needs is negligible. If it is identified at all, sectoral technology is identified at a broad non-specific level. Consequently, the impact of R&D on productivity is not visible. The main factor contributing to weak linkages among stakeholders is that the research conducted by most Research Institutes is not “need-based”

(ii) Due to lack of co-ordination between Industry and Research Institutes, it is difficult for the Research Institutes to ascertain the technological deficiencies faced by the industry.

(iii) Lack of trust/credibility between Research Institutes and Industry adversely affects the process of technology-identification.

(iv) Lack of effective technology-managers in the industry results in low demand for new technology, whether developed locally or imported.

Deficient Foundations for Technology:

a- Human Resources: Every country needs to diversify its knowledge of science and technology, to provide a sound and diversified production-structure in agricultural and industrial sectors. Appropriate manpower-development can play an important role in this regard. However, in many developing countries, human resources are not appropriately developed, for the following reasons:
(i) Scientific and technological research is not having any visible impact on productivity and the Research Institutes are not producing relevant technologies because the quality of scientific manpower produced in the educational institutions and employed in Research Institutes is not up to the international standard. In fact, human resource development is an extremely neglected area. The number of highly qualified research staff is insufficient, and the existing staff is fairly ineffective.

(ii) University teachers are heavily burdened by teaching schedules. The university teacher is spending 75 percent of his time on teaching and hardly 25 percent on research. The research at the university level can be promoted by shifting some of the teaching burden to affiliated colleges and by introducing more research-faculties in universities.

(iii) Due to lack of recognition and rewards, the will to work is missing, and manpower with a scientific culture is scarce. The quality of the manpower could be improved by providing “tenure-track” appointments.

(iv) Effective and competent management in Research Institutes is extremely important for the promotion of R&D activities. Currently, there is a dearth of suitable managers of scientific research in the third-world countries.

(v) Most of the Research Institutes have very few appropriately qualified scientists/researchers. Most RIs have reported manpower-shortage due to the freeze on hiring imposed by the various governments and attrition due to retirement and “brain-drain”; consequently filling the vacant posts is delayed indefinitely.

(vi) Formal education is just one determinant of technological capability; On-the-Job Training (OJT) is equally important. Again, this particular area is weak. Although an apprenticeship system exists in some countries, it is inadequate and not flexible enough to meet the requirements of industrial sector.

(vi) Proliferation of R&D organizations; consequently, manpower in Research Institutes is not evenly distributed.
b- **Research Organizations:** The following factors are responsible for the poor performance of Research Institutes.

(i) Coordination among different stakeholders is currently missing. When a center completes a research project, the findings usually remain unutilized because the completed research may not be commercially viable.

(ii) Turnkey projects are easily available and are sponsored by the government through various incentive-packages. This trend prevents unpackaging of transferred technologies.

(iii) Some Research Institutes do have the latest equipment, but no “trouble-shooting” capabilities. Furthermore, Research Institutes have very little funding for the maintenance of equipment.

(iv) The S&T system is supply-driven, with little incentive to be responsive to the needs.

(v) Not only are the linkages between Research Institutes and industry very weak, but there is a lack of coordination among Research Institutes and within units of larger Research Institutes, leading in some cases to duplication of research effort.

(vi) In university departments, very little resources are devoted to R&D, which moreover tends to be basic instead of applied in nature.

(vii) There is lack of accountability and a reward-system for institutions and individuals engaged in S&T activity, resulting from the absence of a satisfactory mechanism for regular assessment/evaluation of research performance.

c- **Poor Financial Access:** As mentioned earlier, the lack of funds and qualified manpower has affected R&D adversely (Table 2.6(a)). For most of the Research Institutes, the main source of funding is the government. However, some organizations generate additional resources by selling processes and doing trouble-shooting for industry. Development of a working relationship between industry and R&D organizations and the commercialization of products and processes will enable the RIs to generate funds.
### TABLE 2.6 (a)

<table>
<thead>
<tr>
<th>Countries</th>
<th>Govt. (%)</th>
<th>Industry (%)</th>
<th>Foreign &amp; Other Funds (%)</th>
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<tbody>
<tr>
<td>1. Central African Republic</td>
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<tr>
<td>2. Egypt</td>
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<tr>
<td>3. Canada</td>
<td>8.8</td>
<td>52.4</td>
<td>8.5</td>
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<tr>
<td>4. Costa Rica</td>
<td>--</td>
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<tr>
<td>5. U.S.A</td>
<td>11.1</td>
<td>70.3</td>
<td>--</td>
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<tr>
<td>6. Argentina</td>
<td>40.7</td>
<td>30.4</td>
<td>0.8</td>
</tr>
<tr>
<td>7. Peru</td>
<td>25.6</td>
<td>29.2</td>
<td>--</td>
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<tr>
<td>8. India</td>
<td>75.3</td>
<td>19.8</td>
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<tr>
<td>9. Japan</td>
<td>8.3</td>
<td>77.2</td>
<td>0.4</td>
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<tr>
<td>10. Jordan</td>
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<td>--</td>
</tr>
<tr>
<td>11. Korea</td>
<td>11.6</td>
<td>77.3</td>
<td>0.3</td>
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<tr>
<td>12. Kuwait</td>
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<tr>
<td>13. Pakistan</td>
<td>67.6</td>
<td>--</td>
<td>0.3</td>
</tr>
<tr>
<td>14. Philippines</td>
<td>19.1</td>
<td>68.0</td>
<td>3.8</td>
</tr>
<tr>
<td>15. Singapore</td>
<td>10.4</td>
<td>65.7</td>
<td>4.4</td>
</tr>
<tr>
<td>16. Turkey</td>
<td>11.7</td>
<td>37.0</td>
<td>0.5</td>
</tr>
<tr>
<td>17. Austria</td>
<td>5.1</td>
<td>67.7</td>
<td>16.6</td>
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<tr>
<td>18. Bulgaria</td>
<td>64.1</td>
<td>25.5</td>
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<tr>
<td>19. Czech Republic</td>
<td>17.5</td>
<td>66.2</td>
<td>3.1</td>
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<tr>
<td>(Czechoslovakia)</td>
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<tr>
<td>20. Denmark</td>
<td>6.7</td>
<td>66.6</td>
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<tr>
<td>21. France</td>
<td>17.2</td>
<td>63.4</td>
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<tr>
<td>22. Germany (FR)</td>
<td>13.9</td>
<td>69.6</td>
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<tr>
<td>23. Italy</td>
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<td>24. Netherlands</td>
<td>14.1</td>
<td>57.6</td>
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<tr>
<td>25. Spain</td>
<td>16.7</td>
<td>55.5</td>
<td>5.9</td>
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<tr>
<td>26. U.K.</td>
<td>10.0</td>
<td>61.7</td>
<td>17.0</td>
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<td>27. Yugoslavia</td>
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<td>--</td>
</tr>
<tr>
<td>28. Australia</td>
<td>16.0</td>
<td>54.1</td>
<td>2.8</td>
</tr>
<tr>
<td>29. New Caledonia</td>
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</table>

On the basis of available information, the following financial constraints have been identified:

(i) Resource constraints on Research Institutes badly affect their R&D capabilities. Funding, especially for operations and maintenance, is absolutely inadequate. Furthermore the existing meager funds are utilized inefficiently, due to cumbersome bureaucratic procedures.

(ii) Commercialism in R&D organizations does not exist; for instance, the prices charged by industrial research institutes for supply of developed technology are very low.

(iii) Budgetary allocations to Research Institutes are not rationalized.

(iv) Credit is not available from financial institutions for development of technology.

d- Inadequate Infrastructure: The availability of suitably developed infrastructure is a prerequisite, not only for the efficient working of Research Institutes but also for overall economic growth in the country. Most Research Institutes have identified the shortage of capital, chemicals, dedicated manpower and poor infrastructure as major constraints affecting their efficiency. The specific issues regarding the deficiencies in R&D infrastructure are listed below:

(i) Infrastructure services are inadequate and are poorly organized. There is dearth of testing facilities and effective standards-setting agencies.

(ii) Technology leadership appears to be ineffective, due to the lack of high-quality S&T personnel. The use of IT to enhance the effectiveness of these support-services has been neglected. Furthermore, there is dearth of the latest and reliable S&T information.

(iii) Lack of competent consultancy organizations in S&T.

(iv) Provision of infrastructure and power (electricity) and library facilities are basic requirements for the development of technology competence; these are absent in majority of developing countries.

In conclusion, the innovation-process is lagging because of shortage of infrastructure, manpower, and absence of industrial linkage. In order to promote the domestic R&D and industrial linkage, the government should eliminate
double standards for the domestic industry and multinational corporations. Furthermore, an organization should be established to develop linkages among the main agents of technology developers and users.

e- **Regulatory and Legal Environment:** With the changing global economic scenario, the importance of regulatory and legal issues has increased. In this regard, the following issues are important for the RIs:

(i) Licensing and legislative restrictions make it costly, in terms of money and time, to acquire new equipment; furthermore, in order to ensure appropriate selection and better and full utilization of equipment, relevant staff needs to be consulted.

(ii) Local laws are not in harmony with international standards, which adversely affects the transfer of technology.

(iii) Trade policy is not supportive for the development of technology within the country.

(iv) Absorption or assimilation is rarely done, because industries do not employ qualified persons, since turn-key plants are preferred.

(v) There is a lack of motivation in the private sector to use local by developed technologies; they prefer to import turnkey plants, as their suppliers extend them after-sale service, with a possibility of an upgrade; consequently they do not try to assimilate local technology.

(vi) Unplanned efforts to build technological competence have resulted in a shortage of appropriately trained manpower, insufficient data-bases, lack of awareness regarding future needs, and even import of outdated obsolete technologies.

f- **University Research:** In the developing world, universities are mainly degree-awarding institutions, with inadequate budget for research. A genuine transformation of the prevailing environment and attitudes in our academic institutions is urgently needed, as scholarly and creative work is a *sine qua non* for the very existence of a productive university system. Promotions and recognition are unrelated to scholarly excellence and there is little focus on academic and scientific achievement. This orientation
must change and an environment be created that is characteristic of creative academic communities. The widespread malaise of our universities is directly attributable to the poor preparation for both teaching and research, which adversely affects the quality of instructions, as well as the output of research. For achieving excellence in teaching and research, the scientific and technical staff in universities have to be provided with more working facilities and time. Furthermore, a high level of motivation and the requisite conditions for research may create conditions for achieving excellence in teaching and research.
### TABLE 2.6 (b) High – Level R&D Man-Power Breakdown (Thousands) (2005 - 2006)

<table>
<thead>
<tr>
<th>Countries</th>
<th>Total in R&amp;D</th>
<th>Intg. R&amp;D (Industrial)</th>
<th>Non - Intg. (Govt.)</th>
<th>Higher Education</th>
<th>General Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central African Republic</td>
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<tr>
<td>Egypt</td>
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<tr>
<td>Canada</td>
<td>199.06</td>
<td>126.60</td>
<td>16.28</td>
<td>54.73</td>
<td>1.38</td>
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<tr>
<td>Costa Rica</td>
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<tr>
<td>U.S.A</td>
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<tr>
<td>Argentina</td>
<td>49.36</td>
<td>7.87</td>
<td>23.40</td>
<td>16.99</td>
<td>1.10</td>
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<tr>
<td>Peru</td>
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<tr>
<td>India</td>
<td>318.44</td>
<td>53.41</td>
<td>242.93</td>
<td>22.10</td>
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<tr>
<td>Japan</td>
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<td>619.18</td>
<td>63.20</td>
<td>238.81</td>
<td>13.99</td>
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<tr>
<td>Korea</td>
<td>237.60</td>
<td>171.64</td>
<td>19.03</td>
<td>44.15</td>
<td>2.78</td>
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<tr>
<td>Kuwait</td>
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<tr>
<td>Pakistan</td>
<td>53.16</td>
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<td>40.31</td>
<td>12.85</td>
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<td>Philippines</td>
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<td>2.59</td>
<td>1.81</td>
<td>0.16</td>
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<tr>
<td>Singapore</td>
<td>30.13</td>
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<td>2.38</td>
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<tr>
<td>Turkey</td>
<td>54.44</td>
<td>18.03</td>
<td>9.70</td>
<td>26.71</td>
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<td>2.39</td>
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<td>Bulgaria</td>
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<td>2.46</td>
<td>10.26</td>
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<td>Czech Republic (Czechoslovakia)</td>
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<td>10.70</td>
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<td>357.33</td>
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<td>53.42</td>
<td>98.74</td>
<td>6.30</td>
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<tr>
<td>Germany (FR)</td>
<td>485.00</td>
<td>308.00</td>
<td>77.00</td>
<td>100.00</td>
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<tr>
<td>Italy</td>
<td>175.25</td>
<td>70.72</td>
<td>32.68</td>
<td>66.98</td>
<td>4.86</td>
</tr>
<tr>
<td>Netherlands</td>
<td>91.62</td>
<td>49.86</td>
<td>12.63</td>
<td>29.13</td>
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</tr>
<tr>
<td>Spain</td>
<td>188.98</td>
<td>82.87</td>
<td>34.59</td>
<td>70.95</td>
<td>0.57</td>
</tr>
<tr>
<td>U.K.</td>
<td>334.69</td>
<td>149.47</td>
<td>20.10</td>
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<tr>
<td>Yugoslavia</td>
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<tr>
<td>Australia</td>
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<td>16.99</td>
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<td>New Caledonia</td>
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</table>

7. LACK OF ADEQUATELY TRAINED S&T MANPOWER

The serious lack of talented and well trained scientific workers is today the major weakness of the S&T sector in the developing Third World countries (Table 2.6(b)), which must be overcome with utmost speed if the full benefits from the investments in scientific research and development are to be reaped. Modern science requires extensive facilities and an environment of creativity, urgency and challenge for its progress. The human resource-development programme should be arranged in such a way that the present and future R&D needs of the country are met. Mushroom growth of R&D institutes, without a critical mass of relevant highly trained manpower, will not give fruitful results. There are many small institutes manned by only 4-8 scientists of Ph.D qualification, whereas each of these institutes (electronics, biotechnology, renewable energy) should have at least 30-40 Ph.Ds with double the number of supporting M.Sc/M.Phil workers for proper R&D output. In Korea, the Advanced Institute of Science (KAIS) was founded as a postgraduate school in science and engineering. It led the nationwide upgrading of graduate education and contributed to the establishment of a mass supply-system of high-quality scientists and engineers. Also, there was significant expansion of education at all levels. The present stock of S&T manpower in India, for example, is about 2.5 million, the third largest in the world, next to USA and USSR. Beside meeting its own requirements, thousand of qualified Indian scientific workers are currently working abroad. Pakistan has recently launched the programme of training 1,650 young scientists, engineers and doctors in selected high-tech fields for obtaining Ph.D from foreign universities. This critical mass of highly trained manpower could provide the necessary leadership for absorption of high technologies in the country and development of new processes, techniques and products for boosting agricultural and industrial production, as well as streamlining and modernizing the transport, communication and health sectors.

Besides improving the quality and quantity of science-education in schools, colleges and universities, the number of sub-professional manpower should be considerably increased in a progressive manner. The UNESCO-CASTASIA models lay down that the ratio of sub-professional to professional S&T manpower should be of the order 4:1. This lack is one reason why end-users and the professional manpower are working in isolation for solving national problems.

The scientists live in ivory towers without focusing on the subnormal conditions of the people living in the lower strata of the society and those living in the remote and inaccessible areas. Similarly, with the present set-up, industrialists can call the
foreign experts to remove the hurdles on the turn-key projects and the understanding that the technology can be purchased at any cost from the foreign suppliers. Under this divergent situation, the three pillars of science and technology policy (R&D Institute, University and Industry) stand on a weak foundation.

Keeping in view the limitations of scientists and engineers working in the laboratories and the colossal cost-component involved in taking results of laboratory research to pilot-plant scale, many countries have established Research and Development Corporations, to serve as an important link between laboratory research and industry. The main objectives include: (a) commercialization of know-how developed in various research institutions, (b) promotion of inventive talent in the country, through awards and financial aid, (c) bridging technological gaps by promoting developmental projects, in collaboration with industry, and (d) technology-transfer and marketability. These have often proved useful.

**Linkages between R&D Institute, University and Industry:** Appropriate utilization of limited R&D facilities, funds and manpower has been in sharp focus in many recent deliberations in developing countries. The financial experts have often questioned the need to conduct research and to invest limited resources on it, on the plea that (a) there is no demand for research; (b) that the industrialists do not approach the scientists in solving their industrial problems, or (c) they have no faith in the innovations and products developed by the scientists in the local R&D laboratory. In the majority of universities there is no tradition for research and technology-development; where basic research is conducted it often has no relevance to the needs and requirements of the country; and the high-level S&T manpower cannot perform effectively unless proper back-up services are provided by sub-professional manpower, which includes para-engineering, para-medical and para-scientific staff as well as manifold increased skilled craftsmen.

Linkages between R&D Institute, University and Industry manifest in several forms, like contract research, consultancy, exchange of personnel, utilization of research-facilities by industry, testing of materials and use of specialized equipment and facilities of industry by laboratory. It is important that scientists and engineers should visit the industrial units, so as to know their problems and assist in improvement of quality, efficiency of operation and upgradation of technology. As far as possible, R&D institutes should be established in proximity to the end-users. The constant interactions between university teachers,
laboratory scientists and industrial entrepreneurs would solve many problems and considerably reduce the reliance on foreign expertise and technology. It is also important that the fiscal and trade policies should encourage development and adaptation of indigenous technology, a step forward towards self-reliance.

**Proposed Measures for Promotion and Utilization of Indigenous Research**

(i) Those products which are economically feasible should be published for industrialization through the national press, protection being simultaneously offered by the government against cheap imports/smuggling. The scientists/institutions involved in the development work should equally share 10% of royalties on net sales, as an incentive.

(ii) In Germany, the government, through a special bank, provides “risk capital” to industries that are willing to exploit national research. This could be equal to 50% of the total capital-cost of the project. The loan is written off, in case the venture does not prove to be a commercial success. Similar measures for promotion of indigenous research should be adopted in the third-world countries. Such measures can induce our industrialists to invest in the local R&D effort and set up industries based on indigenous researches.

(iii) A Research Utilization Board should be established (with a revolving fund of at least US $50 million), comprising eminent scientists and entrepreneurs. The Board should examine and fund pilot plant-level studies on selected projects.

(iv) A similar strategy should be drawn up for export-oriented development projects.

Each country should develop a long-term S&T Plan for the next 20 years, which should have the important component of manpower-development of various categories.
The following information should be collected to estimate the requirements of S&T manpower for implementation of the S&T policy, in conjunction with the development plan:

- details of programmes and projects of the development plan;
- present position of various categories of scientists and engineers and sub-professionals in R&D institutions, extension and development organizations;
- present vacancies and future requirements, according to scientific disciplines;
- the present enrolment in science and engineering departments of the colleges and universities and their annual output;
- future programmes of expansion and establishing new departments and institutes, and their manpower needs;
- availability of training facilities, through private foundations and international agencies;
- survey of scientists, engineers, doctors and technicians working abroad and their anticipated return, year-wise;
- identification of new and emerging technologies, for which training is required and where facilities are not available;
- projections of requirements of S&T manpower for next 10 and 20 years; and
- balancing of supply and demand of scientists, engineers and technicians.
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3. Abdul Qayyum Kazi, Kind of Information for Formulation and Management of Science and Technology Policy in a Developing Country, UN Asia and Pacific Centre for Transfer of Technology, Bangalore, India 1989, pages 54.


5. UNDP Human Development report 2001


8. UNESCO Science Report 2005, Table 1 (Page 4)


1. INTRODUCTION

In continuation of Chapter-2, analysis of expenditure and manpower for industrial R&D in various countries was further studied; it showed that the industrialized countries and the more developed Asian countries (Japan, South Korea and Singapore) made substantial progress in industrial sector due to liberal allocation of funds and manpower for industrial R&D. Case studies of selected countries (Turkey, Egypt, Malaysia, Bangladesh, Pakistan and South Korea) from various regions of Third World are presented in this Chapter, containing the S&T situation, process of formulation of S&T Policy, main objectives and hurdles in implementing the policy and achieving desired results. In the end, some lessons learned from case studies are highlighted.

2. ANALYSIS OF EXPENDITURE AND MANPOWER FOR INDUSTRIAL R&D IN VARIOUS COUNTRIES

For any attempt to study the relationship between industrial R&D and economic growth, one of the important components is the analysis of R&D Expenditure and High-Level Manpower. These data exhibit some striking features, which have been discussed elsewhere. The first ten include 4 Asian countries, namely Korea, Japan, Kuwait and Singapore, all of which are on the high road to development.
Table 3.1(a) & (b): Data on R&D Expenditure and Manpower, as Rearranged in descending order of % Expenditure by Industry.

<table>
<thead>
<tr>
<th>Serial No.</th>
<th>Country</th>
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<th>Table 3.1(a)</th>
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<tr>
<td></td>
<td></td>
<td>R&amp;D Exp. in Productive Services (% of total)</td>
<td>R&amp;D Exp. in General Services (% of total)</td>
<td>R&amp;D Manpower in Production Sector (% of total)</td>
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<td>~59</td>
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Note: Full data on 2 countries, Costa Rica and Egypt is not available
Fig 3.1: The relationship between the average annual real change in GDP and (a) the % of R&D Manpower in Industry, and (b) the % of the R&D Expenditure by Industry. The economic data is based on those calculated from OECD Economic Outlook: Historical Statistics 1960-1983 (OECD, 1985) and those in the World Bank’s “World Development Report (1992)”, reduced by a suitable factor.
A graphical presentation of this data is reproduced in Fig.3.1(a & b), which indicates significant degree of correlation between the percentage of the R&D manpower in the productive sector and the percentage of the R&D funding provided by Industry, 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**

*R&D Expenditure:* Scientific R&D is a prerequisite for building indigenous capacity. In several developing countries, we find a large number 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 allocation for R&D expenditure in most of the developing countries of the region is around 0.15 per cent of gross national product (GNP). Under these conditions, for obtaining satisfactory results, it would be necessary to concentrate specifically 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.

*Optimise R&D Efforts:* The countries of the region, beginning R&D activities in S&T programmes, may concentrate on one or a few selected S&T applications. Cooperation, between these countries and those already advanced in R&D activities, would contribute to optimizing the R&D efforts for solution of common problems in the regional countries.

*Emphasis on Basic Research as well:* Research in both basic, as well as applied sciences, needs support for long-term gains; basic research is considered essential if the technology development is to become self-sustaining.

*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, even though on a limited scale and sectoral in character, should also be developed in each major applications/user groups.

Considering this situation, some developing countries have formulated the national science policy and are in the process of its implementation as a blue print for S&T activities and development.

3. CASE STUDIES: TURKEY, EGYPT, MALAYSIA, BANGLADESH, PAKISTAN AND SOUTH KOREA

i) Science and Technology Policy in Turkey

Science-policy issues have been given attention in Turkey earlier than in many developing countries and some European countries. The Scientific and Technical Research Council of Turkey (TUBITAK) was established in 1963 following the beginning of the planned economic development period. Among other duties, TUBITAK was charged with the task of assisting the government in formulating the national policy in the field of basic and applied research in positive sciences. However, several attempts made by TUBITAK to develop a national science policy, specially in the early seventies, unfortunately failed to gain general acceptance.

It was in 1981 that the Ministry of State for Science and Technology decided to set up a team of experts to formulate a national science policy. The efforts of over 300 scientists and experts from several organizations including TUBITAK resulted in drawing up the document of the Turkish Science Policy for the period 1983-2003.
Studies were conducted during the formulation of Science Policy to determine the weaknesses in the S&T system. The document on the Turkish Science Policy highlighted the following problems in the system:

- National targets, or objectives for scientific research and activities have not been established.
- Research units have failed to reach the critical size, necessary for efficiency and effectiveness.
- Interdisciplinary research and collaboration at inter-institutional or even at institutional levels cannot be maintained. Thus, there is little or no coordination in research projects, which results in gaps, duplications, insufficiency of size and waste of resources.
- Administrative organization suitable and appropriate for research is lacking.
- The critical amount of qualified human resources necessary for effective research does not exist.
- Critical accumulation of knowledge necessary for effective research has not been achieved.
- Existing research units mostly act in isolation and have insufficient communication with their organizational and scientific environment and with the productive sectors.
- Development of technologies or the generation of technical changes as a result of R&D studies, is not at the desired level.

Considering the above situation and the fact that international competition for science and technological development and transfer will become increasingly difficult in the future, “Turkish Science Policy 1983-2003” was prepared in 1983. In their Fifth-Five Year Development Plan (1985-89), this document was adopted as a starting point for preparation of a science and technology master plan linking with socio-economic targets of the country. The main objectives of the Turkish Science and Research Policy are:

a- Cultural enrichment of Turkey, and achievement of higher levels of scientific competence.

b- Enhancement of the influence of science and technology on the economic and social development of the country.
c- Mobilization of scientific and research capabilities for the strengthening of national defence by developing the relevant technologies.

d- Extension of scientific and research services to production and services sectors for the purpose of developing improved technologies.

e- Enhancement of the level of health and welfare in Turkish society, and the protection of the environment.

To transfer the Policy recommendations into an action plan, measures have been taken to improve institutional and technological structure, manpower development, R&D expenditure and funding, dissemination of technical information and international S&T relations.

The Supreme Council for Science and Technology, was established in 1983 under the chairmanship of the Prime Minister, to perform executive functions and to coordinate R&D efforts with the economic and social development and national security targets. TUBITAK acts as the secretariat to the Supreme Council and is responsible for formulating a science and research plan for Turkey.

The other main features of the Science Policy are enhanced emphasis on basic sciences, defence research and formulating sectoral science and research policies in the areas of agriculture, energy, industries, housing, transportation, health, mining and environment. Further, 72 priority research projects have been identified keeping in view priorities in socio-economic sectoral objectives and such factors as contribution to national development, finance and availability of necessary manpower.

Turkey has now the capability of adapting the technologies required for the manufacture of consumer goods and some intermediate products, but has some difficulty in adapting technologies concerning the production of capital goods. Accordingly, the Policy document contains measures pertaining to technology transfer, improving transferred technologies and enhancement of innovation.

Reliable information-services form an integral component of the science policy. Scientific and Technical Documentation Centre of Turkey (TURDOK) was established in 1969 and offers information and services, in the form of document search and procurement, dissemination, training and consultancy services. The
center is proposed to be expanded so as to evolve into a nation-wide S&T information network.

The lack of positive impact of existing R&D on the economy of the country is due to the fact that research results obtained in various areas (agriculture, industry etc.) have not been properly brought to the notice of the users, in the absence of an appropriate mechanism for their publication, dissemination and adaptation. This could be primarily taken into consideration as an accelerator for further dynamic R&D mechanism. It is therefore essential, that appropriate mechanisms be established for this purpose within the reach of users. These mechanisms should be integrated into the local administrative system, so that research-results may benefit the country as a whole.

Thus, in spite of the potentiality, science and technology alone cannot succeed in solving the complex problems in the developing countries. The governments must be aware of these problems so that, during the implementation of the national scientific and technological policies, appropriate complementary measures should be considered that tend to improve the socio-economic, cultural, and political climate of the society.

It is only under such preconditions that science and technology can be expected to have positive impact on the development of national economy and on the well-being of the nation.

(ii) Science and Technology Policy in Egypt

Lessons learned from the previous/contemporary models of industrialization confirm that import substitution and industrialization, as a stage in the overall process of industrial development, serves effectively in the development of domestic market and provides learning opportunities. The greatest benefits are obtained in the area of developing local technological capacity through the use and, hopefully, absorption of advanced designs and manufacturing processes as well as of sophisticated organization and management techniques. Equally important are the experience and skills acquired in the development of economies of scale, backward and forward linkages, and infrastructure in general. It is noted that achieving substantial progress in these areas collectively is a recognized prerequisite for the society’s advancement to higher levels of import-substituting industrialization and to export-oriented industrialization.
The conditions which prompted action for the formulation of the National Technology Policy (NTP) as a national endeavour of high-level importance, and subsequently for its implementation by sure-footed measures, have probably much in common as regard to the conditions which have prevailed, and continue to prevail today, in many countries of the Third World. These include the following:

- The complex difficulties which the Egyptian economy currently experiences
- The numerous areas of technological dependence
- Isolation of S&T from economic activity

A draft of the NTP was produced in 1984, following a period of intensive preparation that lasted four years, during which, many high-level experts participated and several volumes of policy and sectoral studies were compiled. Meanwhile, three annual national and international seminars on policy issues and several sectoral workshops were held for the purpose of reviewing progress made and for seeking further inputs into the exercise. The preparatory activities and the production of the policy-document were the responsibility of the Academy of Scientific Research and Technology.

The NTP is meant to identify and highlight the technological content of all socio-economic development activities, and to guide action for the proper expression and emphasis of this content. To maximize its effectiveness, it must closely link together with short-term sectoral policies of the five-year national development plans as well as long-term strategy that embodies the vision for the future.

At the operational level, the NTP contrives to transform many of the already existing policy options and general directions to be explicit and to embody these in a coherent nationally acclaimed statement. It also contrives to have its basic orientations implemented without the disruptive influence of subjective inclinations or transient interferences, in order to bear fruits cumulatively and acceleratingly.

**Areas of Action of the National Technology Policy:** The policy prescribes selected areas and modalities of action and indicates the favourable circumstances and supportive instrumentalities, in order to assure the effectiveness of this action. In summary, the policy contrives to concretely produce complementary and mutually reinforcing effects in the following areas of action:
a- Stimulation of the national technological capabilities to increase their inputs, while encouraging demand on these inputs vis-a-vis inputs from foreign sources, both qualitatively and quantitatively, through strengthening of the local innovative-adaptive-productive capacities and coordinating their contributions.

b- Regulation of the flow of foreign inputs for the acquisition of technology, while applying fair terms and conditions, with a view to maximizing their benefits and maintaining a socio-economically favourable balance between these inputs and those from indigenous sources and, in particular, with regard to the needs of production in terms of technology-embodying inputs of goods, services, and process know-how.

The size and diversity of Egypt’s economic problems: the pressures resulting from the absence of vast natural resource endowments and the rapidly increasing population; the prospects arising from the possession of a sizeable science and technology (S&T) institutional infrastructure and manpower; and the current and independent world-wide S&T breakthroughs, all have combined to bring about rapid technological transformation in Egypt. The National Technology Policy (NTP) has been conceived to provide a conceptual framework for such transformation as an overall national drive and more specifically to reduce the rate of technological dependence by producing the needed infrastructure to achieve higher-level import-substituting and export oriented industrialization. What needs to be substituted or replaced is not only the import of goods, but also the import of technologies and the means of production.

It is emphasized that much of the effect of the NTP hinges upon the acquisition of an organized capability for the early unpackaging of needed technology. This involves a systematic analysis of the national needs of embodied and disembodied technologies, in order to identify those needs which can be provided by the use of local capabilities and resources as distinct from those which, otherwise, must be obtained from foreign sources. Another important realization is that the policy and the process of all-round technological transformation should receive support at the highest level of political and social authority. The areas of major recommended action in the implementation of the NTP are as follows:
a- Actions for developing indigenous technological capabilities:

These include specific actions for strengthening of the national R&D institutional infrastructure and improving its performance. Specially important are the complementarity between and inter-dependence of the performing units, the pursuance of reverse engineering methodologies, the encouragement of applied R&D, intensification of design, and engineering contributions. Another important facet of the NTP is the creation and support of lead-sector technologies in selected fields of production.

b- Actions for maximizing the benefits of foreign technological inputs:

The main instrument prescribed for this purpose is the law on the transfer of technology. The basic orientation of the NTP in this area has the objective of assuring that the transfer of technology transactions are concluded under fair terms and conditions and that the transfer does, in effect, produce socio-economically beneficial results. The policy also calls for attention to foreign S&T relations as a resource which deserves tapping and optimization.

c- Actions for interacting with contemporary sciences and technologies:

The major emphasis here is on action for promoting social acceptance of S&T and for the initiation and nurturing of national activities in the fields of selected frontier sciences and technologies.

iii) Science and Technology Policy in Malaysia

Science and Technology (S&T) are integral components for economic development, national security and welfare of the people, which are usually the fundamental concerns of any government. Scientific research and development (R&D) is therefore essential for the governments to achieve their goals, which include industrial development, defense, health, provision of food, shelter, energy, environmental protection, sustainable use of natural resources, transport and communications. Consequently, science and technology is part of the socio-economic development package (a concept brought into focus for the developing countries, initially, by the United Nations Conference on the “Application of Science and Technology for Development”, held in Vienna in 1979), which recommended wide-ranging measures at the national, regional and international
levels for strengthening the S&T capacities of the developing countries. Major areas of concern were related to S&T policy and institutional arrangements.

UNESCO, has initiated several regional ministerial conferences on the application of science and technology for development, to address essentially the same issues and to make recommendations. These began with CASTALA 1 (1965), CASTASIA II (1968), CASTAFRICA 1 (1974) and CASTARAB 1 (1976).

Despite the above and subsequent conferences, the developing countries of the world are still largely inexperienced in the matter of S&T policy and, more importantly, its integration into national development planning.

Malaysia’s development programme has been formulated on a five-year time-frame and, while formulating the Fifth Malaysian Plan (FMP) (1986-90) an opportunity arose for S&T issues to be examined inter-sectorally during the planning for the FMP and so a chapter on science and technology made a maiden appearance in the FMP document, effectively integrating S&T planning into the national planning mechanism. In view of the push towards industrialization and the emphasis on value-added and other down-stream activities during the FMP period, the above move, vital to the success of development objectives, came at a very opportune time.

A National Science and Technology Policy (NSTP) has been formulated and approved by the Government in 1986. Its Policy Statement proclaims that the NSTP, being part of the socio-economic development policy of the nation, has the following objectives:

a- To promote the utilization of S&T as a tool for economic development, the improvement of human physical and spiritual well-being, and for the protection of national sovereignty.

b- To promote scientific and technological self-reliance in support of economic activities, through the upgrading of R&D capabilities by the creation of an environment conducive to scientific creativity, and the improvement of scientific, educational, and other relevant infrastructures.

The major contents of the S&T Policy Document discuss inter-sectoral issues and strategies, and include the following:
a- Integration of the NSTP with other policies
b- Development of the national scientific potential and S&T self-reliance
c- Development of science-information system and science indicators.
d- Development of R&D infrastructure and centers of excellence.
e- Development of appropriate coordination and monitoring mechanism
f- Financial allocation to R&D
g- Manpower development
h- Role of the universities and the private sector
i- Mechanism for technology-transfer
j- Commercialization of results of research.

In recent years, Malaysia has made some major gains in its S&T infrastructure, both in the planning and management and the implementation aspects. More importantly, S&T planning is now an integral part of the national socio-economic development process.

IRPA, as procedure for R&D budget justification and allocation and as an approach to strategic planning for S&T development in targeted areas, is perhaps unique among developing countries. However, continuous improvement and refinement is considered necessary.

Many constraints still exist and need correction: organizational and institutional changes that are necessary to streamline the planning and management process and the implementation machinery. With respect to R&D activities, upgrading research capability involving the updating of equipments, training and retraining for specific skills in new areas, international collaboration, etc., are matters of some urgency.

In the development of industrial technology, access to many of the fiscal incentives by industry and ease of movement of personnel between public and private sector institutions are some of the issues needing improvement. A need is also felt for the establishment of a research fund for industry to encourage product or process improvement and development. Various forms of this type of fund are in operation in many other developing countries, which Malaysia can use as models for its own need.
In the area of commercialization of research results, a major constraint currently is the virtual absence of a venture-capital market. However, the Bank Negara Malaysia is committed to encourage the growth of this sector of banking activities and several banks have shown interest, especially in supporting new companies in the Technology Park.

Both Malaysia and South Korea have been able to have an export growth-rate of nearly 15% per annum in their manufactured goods during the last two decades, while also diversifying their economies considerably. This has been based on a combination of well-planned industrialization with appropriate S&T manpower-development and attention to human priority-concerns.

Malaysia (with a population of about 15 million) had the target to ensure that they have, by the beginning of the 21st century:

- 56,000 local engineers, with 130,000 engineering assistants or technicians;
- 5,000 more medical doctors, with 10,000 medical and health assistants; and
- 75,000 science teachers by the end of century.

The government plans to launch several projects to popularize science and mathematics in schools and higher institutions of learning, so as to be able to have staff for the 277,000 science-based posts in the country by the year 2,000 A.D. Moreover, the Ministry of Science and Environment has proposed to set up R&D centers in those States where specific products and production-sites exist.

On the Industrial Research side, there has been consistent effort to integrate research with the productive sector, both Agriculture and Industry. Thus, their Agricultural Research & Development Organization (MARDI) is now participating in commercial venture, 10% of the funding for which (60 million Ringitt) would be provided by the Government. Similarly, their Standards and Industrial Research Institute not only bring Standards, Certification and Research under one umbrella, but is making steady progress with Technology Transfer to Industry.

Malaysia has shown export growth-rate of nearly 15% per annum in the manufacturing goods, as well diversifying the economy. This is based on a combination of well-planned industrialization with appropriate S&T manpower development, and attention to human priority concerns. Malaysia had earlier
embarked on one of the largest manpower-development programmes by sending thousands of young students for under-graduate, graduate and post-graduate studies in various foreign universities of repute. Besides, other priority areas are; (i) popularization of science and mathematics in schools, (2) integration of research with production-sector, and (3) standardization and quality-control.

Effective utilization of natural resources and establishment of R&D centres in those areas where specific product and production-sites exist have played a pivotal role in the recent industrial development of Malaysia.

iv) Science and Technology Policy in Bangladesh

Bangladesh formulated a National Science and Technology Policy in 1980 with the primary aim to attain S&T competence and self-reliance, to contribute to the world-wide pool of S&T knowledge, recognize high talents in various areas of S&T, to strengthen international/regional S&T cooperation, to be in consonance with other national policies, and provide guidelines for institutional arrangements in the R&D structures to achieve these objectives. The major elements of the S&T Policy are:

- Organization and coordination all R&D work concerning science and technology in the country.
- Careful selection of major problems facing the country in each vital sector.
- Promotion of research and strengthening the competence and capability of research institutions, including the universities.
- Establishment of S&T institutions in selected areas of national importance
- Improvement of standard of scientific knowledge, at all levels from the School to the University level.
- Training of personnel and specialized scientific and technological staff.
- Ensuring suitable environment for S&T research.
- Creation of scientific awareness among the general masses of people, including the young generation.
- Development of national capability for development of indigenous technology.
- Creation of centralized facilities for collection and dissemination of scientific information and research findings.
• Ensuring adequate funds for the S&T sector, for development of infrastructure for R&D activities.

• Ensuring bilateral, sub-regional, regional and international S&T collaboration.

The working Government of Bangladesh constituted the National Committee on Science and Technology in 1983, headed by the President of the People’s Republic of Bangladesh to ensure the implementation of the S&T Policy and its decisions and accord approval of research plans and programmes.

However, it has been reported that the S&T Policy consisted mostly of broad objectives, without definite guiding principles, and did not form a part of the over-all national development plan and so no concerted effort has been made for implementation of the policy.

v) Science and Technology Policy in Pakistan

Pakistan is perhaps the only country in the region that has a well documented National Science and Technology Policy, duly approved by the Government in March 1984. The exercise for the preparation of the Policy started in 1975 and culminated in 1984. All the steps involved in the formulation of the Policy have been properly documented. In 1975 the Ministry of Science and Technology took four steps for the preparation of a National Science and Technology Policy:

• National Steering Committee

• Creation of a Science Policy Cell (SPC) in Ministry of Science and Technology

• National Science Council was assigned the task to develop recommendations for the National Science and Technology Policy.

• Four Working Groups were constituted to frame recommendations for the S&T Policy.

The Working Groups were assigned the following areas (i) Building up of Scientific and Technological Capability (ii) Application of Science to Development (iii) Social and Cultural Determinants of Science and (iv) Planning and Financing of Science and Technology. The SPC prepared the first Draft Proposals for S&T Policy which was discussed in two Scientists Moots at Islamabad and Karachi.
Ministry of Science and Technology, in collaboration with Pakistan Science Foundation and US National Academy of Sciences organized a Workshop on National Science and Technology Policy-Planning and Implementation held at Peshawar in October 1976. About 60 Pakistani scientists and 9 US Experts participated. The delegates of this Workshop reviewed, analysed and recommended sectoral priorities for research and development to develop Pakistan’s scientific and technological capabilities for effective support of national economic development. Seven discussion-groups deliberated on priority areas, application of existing knowledge, institutional needs, personnel and financial requirements. The draft proposals/recommendations were used in the formulation of S&T policy.

The Science Policy document was revised several times in consultation with Provincial Governments, eminent scientists and engineers, universities, R&D institutes (1977-1981).

A Draft S&T Policy document was submitted to the Cabinet in 1981, and a Cabinet Committee headed by the Minister for Finance and Planning was constituted to examine the draft and submit the revised draft to the cabinet. The Chairman Cabinet Committee authorized submission of the revised S&T Policy; it was approved by the Cabinet on 4 March 1984, and it directed that an Action-Plan for its implementation be prepared: this was prepared in consultation with relevant ministries, R&D organizations and provincial governments.

The main objectives of the National Science and Technology Policy are to re-organize and develop a dynamic, efficient and a self-reliant science and technology system in the country and to ensure that this system is directed towards the achievement of national goals and aspirations such as the welfare of the people, sustained growth of the national economy and security of the country.

Some of the salient features of the Policy proposals are:

- the S&T System be so restructured as to fill in the existing gaps to facilitate the formulation, implementation and evaluation of coordinated action-plans based on S&T Policy;
- greater autonomy and intellectual freedom be allowed to S&T organizations and workers so as to provide full freedom for the creative talent in science;
• R&D Centres be created in industry for achieving increased productivity and improved quality of products;

• Requisite S&T structures be set up at the provincial and local government levels in order to ensure maximum participation and direct involvement of the people at large in the evaluation and application of site-specific technologies;

• Working conditions of scientists be improved and they be provided a career-structure commensurate with their intellectual/professional attainments;

• International cooperation in S&T fields be promoted, in order to break the isolation of Pakistani scientists for acquisition of technology from active centers of research in the world;

• Steps be taken to achieve greater self-reliance in development of technological capability as an integral part of the national strategy for self-reliance;

• An effective process of accountability at all levels be evolved, in order to ensure that the nation gets a satisfactory return on its S&T investment.

The Policy warrants its review after every five or ten years in order to synchronize with successive five-year development-plan preparation. Accordingly, an exercise was carried out in 1989, wherein 40 working scientists discussed the revision of the Policy, keeping in view the present socio-economic trends and rapid changes taking place in the S&T sector. However, this exercise was not very fruitful, indicating that further time be allowed to observe the effectiveness of the present Policy. Some scientists were of the view that functioning of the National Commission for Science and Technology and its Executive Committee and the Science and Technology Committees of the Senate and National Assembly should assist in resolving the problems and give directives to the concerned agencies for making use of science and technology system. The S&T Policy has paved the way for formation and implementation of the National Technology Policy and Information Technology Policy.

The investment in R&D has increased appreciably over the past decade but the research results are not commensurate with the expenditure in S&T sector:-
There is need for (i) Prioritization of R&D areas; (ii) Maintaining balance between basic research and applied research; (iii) Undertaking industrial research which has immediate demand; (iv) Dissemination of required information to end users; (v) Regular surveys on S&T indicators; vi) Development of a core of good service managers.

vi) Science and Technology Policy in South Korea:

The new Korean S&T Policy initiatives/directions in the 21st Century are a drastic departure from the past S&T policy, which was geared primarily toward industrialization. The main components of the present Science and Technology Policy-Directions are summarized below:

a- Science and Technology Policy Directions for the 21st Century

- Five year Plan for S&T Innovation.
- Vision for Science and Technology Development for 2025.
- Regional Science and Technology Promotion.

b- Science and Technology Policy

- National R&D Programme:
  - The 21st Century Frontier R&D Programme
  - The Highly Advanced National Project (The HAN Project).
- The Creative Research Initiative
- The National Research Laboratory
- Biotechnology Development Program
- Space and Aeronautics Program

c- International S&T Cooperation:

- International Joint Research Program
- Bilateral Cooperation with USA, Japan, China, Germany, OECD, etc.
- Multilateral Cooperation.
d- Basic Research and High-Caliber Manpower:

- Enhancement in basic research expenditure
- Centres of Excellence
- R&D Equipment, Materials and Information
- World-Class Institutions
- High-caliber Manpower.
- Research-oriented Institutes
- Science and Technology Education

d- Public Awareness of S&T:

Recognizing the importance of Science and Technology as vehicle for economic development, South Korea, a resource-poor country, relied on S&T to achieve the level of industrialization in just 40 years that had taken Britain 200 years, the USA 150 years, and Japan 100 years to achieve. South Korea hopes to achieve the above S&T directions by boosting R&D spending to 6.7 percent of GDP by 2010.

The strategy adopted by Korea was to emphasize a multi-pronged approach comprising (i) manpower development at various levels; (ii) accelerated introduction of advanced foreign-technologies; (iii) promotion of indigenous R&D activities; and (iv) tax-legislation and financial incentives, making R&D mandatory for industries. Korea is presently employing nearly 65% of its R&D manpower in the productive sector, while over 80% of R&D expenditure is provided by the productive (industrial) sector.

4. SOME LESSONS LEARNT

A policy is the reflection of a country’s aspirations and the commitment of its government. It is the outcome of the concerted efforts of different groups of people.

There are a lot of factors which affect the formulation and implementation of a policy and a S&T policy is no exception. The political commitment, S&T climate, effective intermediaries, linkage among R&D institutes and industry,
and qualified and trained S&T manpower development are among such factors which affect the formulation and management of a S&T policy.

In order to have a successful S&T policy the system of formulation and management of a S&T policy, needs to be dynamic. Such a system should ensure that S&T policy is formulated to achieve the long-term and short term objectives of national development plans and any change in the national priorities needs to be incorporated in the Policy.

S&T projects take 5 to 10 years for fruition, therefore it is imperative to plan in a 10 year or 20 year time-frame in the first instance, so that the outputs from educational reforms and innovative programmes have sufficient time to reach fruition and wide dissemination.

**Concluding Remarks:** S&T Policy is a comprehensive statement by the highest policy-making body of Government to guide, promote and regulate S&T activities for national development. It contains statements of aims and objectives, of principles and purposes and of commitments of government for S&T in terms of required manpower, services and financial input.

There is a need for a formal mechanism, a sort of national council/committee/commission for S&T to finalize policy-formulation in collaboration with concerned ministries, R&D institutes, universities and stakeholders.

A policy that is truly public-sector supported, private sector-driven and performance-based can be formulated and implemented solely by the practitioners on the ground. The policy-formulating body should draw up the organizational structure and operational mechanism and specify the responsibility of each group to handle implementation of the different policy instruments.

The country should develop the ability to recognize the obstacles facing the current economic development and meet these challenges through creating an S&T Policy including research and development component. The real effectiveness of the S&T Policy can only be assessed after it is implemented. Necessary revisions should be made expeditiously, if so required.
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1. SCIENCE AND TECHNOLOGY AS A COMPONENT IN THE DEVELOPMENT PROCESS

Planning of science and technology itself is a relatively new concept. The preparation of S&T Plan, as an integral part of socio-economic plan, can only stem from a purposeful science and technology policy, which lays down directions for scientific efforts and identifies areas of technological improvement to sub-serve the national goals. Many developing countries prepare five-year development plans, each of which is further broken into annual development plans. The annual plan often has been a flexible document, in line with the overall plan objectives, making adjustments in the light of progress made earlier.

Only in the last 25-30 years have serious attempts been made in Third World countries to incorporate the S&T sector in the development-plan, indicating separate allocation for S&T activities. Some of these have been analyzed in the following sections. Two examples frequently used are those of India and Pakistan, which have seven decades of history of some sort of S&T planning.

Sustainable Development

1. The Concept of Sustainable Development:

The concept of sustainable development was launched by the Brundtland Commission on Environment Development in the report “Our Common Future’...

* Based in part, on a paper published in Pak. J.S.T.P & Scientometrics, Vol.4(2), 2005
in 1987 and it was reinforced by the UN earth Summit in Rio de Janeiro (1992), further followed and developed by the announcements and recommendations by other regional and international conferences. The Brantland Commission defined sustainable development as the process to meet the needs of the present generation without compromising the needs of future generations. It is important that meeting the needs of the poor in this generation is an essential aspect of sustainability, meeting the needs of subsequent generations. There is no difference between the goals of development policy and appropriate environmental protection. Both must be designed to improve welfare.

Many Islamic countries have not yet achieved acceptable living-standard for their people. Economic growth that improves human welfare is urgently needed. The World Development Report 1992 suggested a threefold strategy for meeting the challenge of sustainable development viz:

- Build on the positive links: Policies that are effective in reducing poverty will help reduce population-growth and will provide the resources and knowledge to enable the poor to take a long-term view.
- Break the negative links: Rising incomes and technological advances make sustainable development possible, but they do not guarantee it. Effective environmental policies and institutions are essential.
- Clarify and manage the uncertain links: Investment in information and research and the adoption of precautionary measures, such as safe minimum standards, where uncertainties are great and there is a potential for irreversible damage or high costs in the long run.

The sustainable development hinges on proper balance of actions of a few rich people, on one end and the millions poor people at the other end. The advanced countries, with high per-capita income, spend more lavishly on home comforts, communication, more & nutritious foods, liberal use of energy resources, fighting new diseases and, in turn, causing air, water and environmental pollution; the poor in the developing countries suffer for want of minimum daily-food, diseases, poverty and natural disasters often due to their own actions like soil erosion, deforestation, etc. The meetings, workshops, TV programmes, newspapers and other electronic media can play an important role to educate the people on the street about interactions between environmental and economic development and the consequent effects on sustainable development.
2. Human Activity and Negative Sustainable Development:

The indiscriminate use of limited natural resources has continuously led to environmental degradation, unsustainable development and human miseries. For instance, the process of desertification causes severe soil-erosion, declining agricultural productivity, increased cost of food production, reduced rural income, flight of population to towns and cities, ultimately leads to social and political instability. Another area that needs immediate attention is climatic change, which is damaging human development. In drought-prone countries of the Islamic world, children aged five or less are respectively 36 and 50% more likely to be malnourished if born during a drought. In Niger children aged two or less born in a drought-year where 72% more likely to be stunted. Climate change will effect rainfall, temperature and water-availability for agriculture in vulnerable areas. Changed run-off patterns and glacial melt will add to ecological stress, comprising flows of irrigation water and house settlements in the process. Sea level could rise rapidly, with accelerated ice-sheet disintegration. Global temperature increase of 3-4°C could result in 330 million persons being permanently or temporarily displaced, through coastal flooding (e.g. Bangladesh, Maldives, Pakistan). Around one half of the world’s coral reef systems have suffered as a result of warming seas. Increased acidity in the oceans is another threat to marine ecosystems. Climate change is providing avenues for major killer-diseases to expand, additional millions of people are exposed to malaria and dengue fever. The human activity in the process of development leads to disaster and unreparable damages, if not properly managed.

3. Actions Required Toward Sustainable Development

The Islamic countries shall cooperate in the exercise for utilizing natural resources and traditional plant and animal species in order to produce and conserve the energy and reduce carbon emissions. Setting targets for sustainable development is a first step. Translating targets into policies is politically more challenging. Some of the priority areas for R&D at national and regional levels are mentioned below:

- Multidisciplinary approach to forecast, monitor and maximize natural hazards, like floods, storms and earthquakes
Determination of the carcinogenic, mutagenic and teratogenic effects of various known pollutants and control of communicable diseases

Industrial research on processes for reducing solid, gases and liquid wastes, and ensuring better waste utilization.

Intensive experiments to determine effects of sea and river pollutions on growth and planktons of fish and plankton.

Development of salt-tolerant crops, adapted to withstand the arid environment, and introduction of species to check the desertification process.

Pool the resources and expertise to conserve the ecosystem and to utilize the biodiversity for the beneficial purposes (e.g. biotechnology in improving agricultural productivity)

Identification of appropriate and legitimate mechanisms for the monitoring and regulation of actions that affect the environmental process.

The comprehensive and far-reaching program of actions for sustainable development is given in Agenda 21, adopted in 1992. It has not been implemented in Islamic countries. Regional cooperation and coordination activities within the ISESCO system are crucial for economic development. And, above all, the Islamic countries should collectively participate in the programs launched by various organs and institutions of the United Nations.

Considering the importance of sustainable development and its daily effects on all section of the population in the Islamic countries, it is proposed to create a separate Authority for Sustainable Development to identify appropriate and legitimate mechanisms for the monitoring and regulations of actions that affect the environment and development process.

Environment and Climate-Change:

Climate-change is different from other problems facing humanity and it compels us to think differently at many levels. Climate-change is a global challenge and requires a global solution. Climate-change is already having significant impacts in certain regions of the Islamic world, particularly the least developed countries, and will affect the ability of developing countries’ of Islamic world to achieve the Millennium Development Goals (MDGs).
Climate-change threatens to erode human freedoms and the limit choices. The warning signs of the impact of climate-change are already visible. Today, we are witnessing, at first hand, what could be the onset of major reversal of human development in our lifetime. Across the Islamic world, millions of the poorest people are already facing the impacts of climate-change. How the Islamic community deals with climate-change today will have a direct bearing on the human development prospects of a large section of humanity. It will increase the inequalities within countries and it will undermine efforts to build a more inclusive pattern of globalization, reinforcing the vast disparities between the ‘haves’ and the ‘have nots’.

The source of climate change is the “blanket” of greenhouse gases that occurs naturally in the atmosphere and serves the vital function of regulating the planet’s climate.

**Combating the Greenhouse Emissions:** Since the start of the industrial revolution some 250 years ago, emissions of greenhouse gases have been making this blanket thicker at an unprecedented speed. This has caused the most dramatic change in the atmosphere’s composition since at least 650,000 years ago. Unless significant efforts are made to reduce emissions of greenhouse gases, the global climate will continue to warm rapidly over the coming decades and beyond.

The future rate of accumulation in greenhouse gases will be determined by the relationship between emissions and carbon sinks. There is bad news on both fronts. By 2030, greenhouse gas-emissions are set to increase by 50 to 100 percent above the levels of year 2000. Meanwhile, the capacity of the Earth’s ecological systems to absorb these emissions could shrink. This is because feedbacks between the climate and the carbon- cycle may be weakening the absorptive capacity of the world’s oceans and forests.

The first phase of the Kyoto Protocol calls for a 6-7% reduction of greenhouse-gas emissions below the 1990 levels by 2012, while the IPCC calculates that a 60-70% reduction in emissions is needed to stabilize atmospheric concentrations of greenhouse gases. It is necessary that only that amount of CO2 be emitted into the atmosphere which can be absorbed by natural processes and, at present, we are overloading this capacity by 10 and 50.
Role of Developed Countries and Worsening Situation of the Poor, due to Climate-Change!

Developed countries have to take the lead. They carry the burden of historic responsibility for the climate-change problem, and they have the financial resources and technological capabilities to initiate deep and early cuts in emissions. Putting a price on carbon, through taxation or cap-and-trade systems, is the starting point. But market-pricing alone will not be enough. The development of regulatory systems and public–private partnerships for a low-carbon transition are also priorities.

Across the developed world, public concern over exposure to extreme-climate risks is mounting. With every flood, storm and heat-wave, that concern is increasing. Yet climatic disasters are heavily concentrated in poor countries. High levels of poverty and low levels of human development limit the capacity of poor households to manage climate-risks. With limited access to formal insurance, low incomes and meager assets, poor households have to deal with climate-related shocks under highly constrained conditions. What is saddening is the fact that the poor are already suffering, and will suffer more, as a result of climate change.

Need for Immediate Action:

The average global temperature has risen by 0.74°C during the last century, which is the fastest warming-trend in history. This trend is expected to rise in the future, as predicted by the climate projections. This situation needs to be addressed urgently by the Islamic world, in collaboration with the rest of the world. Climate-change has the potential to create human disasters, ecological collapse and economic dislocation on a far greater scale than we see today. It has direct impacts on our environment, such as more floods, pest infestations in forests; damage to agriculture and marine systems, and threat to one of the essential resource, water. Climate-change also indirectly affects all sectors of human activities.

The impacts of climate-change are having numerous adverse affects, one of which includes the worsening situation of the poor people. Disastrous events, such as tsunami in 2004 and 2006 earthquake in Pakistan, need to be countered
proactively. Islamic countries should develop an action-plan encompassing precautionary measures to avoid such devastating damage. The problem of climate-change has to be resolved at present, or else the consequences will be unavoidable in the future. **Intermediate action is imperative.**

**The Islamic world needs to act now!** Only then will it be possible to keep 21st Century global temperature-increase within a 2°C threshold above pre-industrial levels. Achieving this future will require a high level of leadership and unparalleled international cooperation. Yet climate-change is a threat that comes along with an opportunity. Above all, it provides an opportunity for the world to come together, in building a collective response to a crisis that threatens to halt future progress.

With climate-change, every year of delay in reaching an agreement to cut emissions adds to the greenhouse-gas stocks, locking the future into a higher temperature. It should also be kept in mind that greenhouse-gas emissions have the same impact on the atmosphere, whether they originate in Indonesia, Saudia Arabia or Sudan. Consequently, action by one country to reduce emissions will do little to slow global warming, unless other countries act as well. **Collective action is imperative,** as no one country can win the battle against climate-change acting alone.

Adaptation is a process, through which societies make themselves better able to cope with the risks associated with climate-change. These risks are real and already happening in many systems and sectors essential for human livelihood, including water-resources, food-security and health. Delay in adaptation by Islamic countries will mean increased costs and greater risks to humanity in the future.

Governments of Islamic countries can play a major role by constructing policies and measures that address climate-change, including regulations and standards, taxes and charges, tradable permits, financial incentives, research and development programs, and information instruments.

Discussions on climate-change are moving with a new sense of urgency and openness, all around the world. Climate-change has been included in the agenda of several important international and regional meetings. The Islamic world needs to realize the importance of collaborating with the rest of the world, and moving ahead, to resolve the issue of climate-change.
2. MANPOWER DEVELOPMENT FOR INDUSTRIAL RESEARCH:

The development of high-level S&T Manpower is one of the crucial factors in modern Industrial Development. Every country must develop sufficient manpower to fill the needs of the various sectors viz. educational, industrial and research. In case of Pakistan, from being near leaders of the Muslim World in S&T in the nineteen fifties, it has over the years fallen to fifth or even sixth place in the Muslim world: at least three of the fellow Muslim countries have overtaken Pakistan in this vital sector.

Pakistan:

The history of S&T manpower development in Pakistan has a checkered record. During the life-span of 50 years, Pakistan has undertaken an organized programme of manpower development only a couple of times. At the very beginning, Pakistan got a flying start in the matter of S&T manpower through: (a) a small band of senior S&T workers who came over to Pakistan in the late forties and early fifties, (b) about two hundred trainees of the pre-independence Government of India, who had been sent abroad under the British-India Post-war Reconstruction Programme in 1945 and 1946, and who thereafter opted to serve Pakistan. Starting from this small beginning in the early fifties, several applied research organizations grew up in Pakistan, notably the PCSIR, the PAEC and the PARC, partly by inducting some high-level manpower that would ordinarily have gone to the universities then being built up. Pakistan has relied heavily on foreign technical assistance for its high-level manpower development. The main contributors in this early effort were: (i) U.K., Canada, Australia, and subsequently Japan under the ‘Colombo Plan’ technical assistance programme, (ii) United States of America under the USAID and Fulbright programmes, (iii) in the sixties and early seventies, some training facilities were also provided through the CENTO economic programme.

These programmes, together, would have contributed 4,000 to 5,000 trained scientists & technologists to Pakistan in the first 2 decades. Inspite of this input of technical assistance from various foreign sources, the development of S&T manpower in Pakistan has been inadequate, quantitatively as well as qualitatively. The major shortcomings in the foreign technical-assistance programs are:
• Absence of a master training-plan identifying the existing manpower in the various sectors, the requirements over a period of 10 years and a phased plan of action.

• Long bureaucratic procedures for processing of foreign-training cases through the channels of Provincial and Federal Governments, resulting in non-utilization of a large proportion of training facilities offered by international agencies and foreign governments.

• Lack of proper knowledge in government departments and autonomous bodies about the availability of specialized fields of training in foreign universities and research institutions.

• Faulty identification of the training needs of Pakistan by foreign agencies, ignoring (sometimes willfully) the most critical areas where technical assistance could really help Pakistan build a sound indigenous S&T manpower-base for its development needs.

• Lack of proper utilization of trained manpower, after completion of training, resulting in “brain-drain” or mis-match of qualification and job.

Inspite of these deficiencies, all these efforts pooled together constitute a base of 1,80,000 scientists and engineers in Pakistan, which is about one-third of the recommended level, in accordance with the barest minimum UNESCO criteria proposed for countries with comparable per-capita G.N.P. or in comparison with similar neighboring countries. The situation regarding manpower engaged in research & development is even worse. According to the UNESCO criteria the minimum recommended level of R&D manpower is 10% of total S&T manpower, against which we, in Pakistan, have a pool of only about 7,000 high-level R&D personnel. This situation is almost static since 1980 and the recent trend was towards decline, rather than any improvement. The fact is that, from being near leaders in S&T in the Muslim world in the nineteen fifties, we have over the years fallen to 5th or 6th place! Atleast three of our fellow Muslim countries have overtaken us in this vital sector. Therefore, it is high time that we set atleast an interim minimal goal to plan to regain the ground lost in the previous two decades.
Realizing the shortcoming in the foreign technical-assistance programmes and their inadequacy to meet the challenges of preparing S&T manpower in high-technology areas critical to the development of self-sustaining economic growth, the Ministry of Science and Technology in Pakistan launched the S&T Scholarship scheme in 1985-86, providing for 400 scholarships per year for Ph.D. and M.Phil level training in some high-tech areas. However, the number of scholarships was reduced later from 400 to 200 and later on to 100 per year, due to lack of political will and financial resources. In addition, the Ministry of Education offers some scholarships under the Central Overseas Training programme and “100-merit Scholarship Scheme”. These scholarships are mostly in academic fields and they are not tied up with the critical shortages in the high-tech areas.

At this rate, it would take at least 10 years to make up for the past shortage of 10,000 high-level R&D manpower, let alone build adequately for the future! What we really need is a vigorous programme of training at least 2,000-5,000 research scientists and engineers each year for the next decade, followed by a substantial leap thereafter, so as to attain not only the minimum recommended level according to the UNESCO criteria, but also to have a sizeable number of high-level R&D personnel working within industry (c.f. the figure of 23,000 in Korea around 1985). Hopefully, about one-third of those trained each year could be inducted into Industry for Quality-control, Product-development and thus progress on towards actual R&D.

i) Some Future Projections for Pakistan: The objective being to place Pakistan in its rightful place in the Muslim World in S&T by the year 2,015 A.D., we need to produce enough S&T manpower for all the potential users of S&T manpower. These users are: Industry, Universities, R&D Institutes, Professional Colleges, Polytechnics, Science Colleges & High Schools. Taking a present figure of 22 Universities, 450 Degree colleges, 2,000 Intermediate Colleges and High Schools, 100 Polytechnics, on the educational side, together with 100 R&D Institutes and several hundred Industries on the Development and Production side, we can project the following yearly intake or “utilization” of High Level R&D manpower i.e. M.Phil. & Ph.D together with some supporting M.Sc. levels, so as to come up (in the year 2015) to the minimum figures recommended by UNESCO (~ 500 per million population) for the developing countries.
It would be seen that the projections given in Table 4 should give the country something like 50,000 High-Level Scientists & Technologists (Ph.D. & M.Phil.) by 2,015 A.D., out of which about 10,000 would be working in industry. Of course, these would be supported by another 26,000 M.Sc’s or B.E’s. If this target is in mind, Pakistan could then hope to achieve the sort of development that Korea has today, provided similar inputs of essential laboratory & supporting facilities are also forthcoming.

**ii) Greater Market Relevance: Updating of Syllabi:**

(i) The syllabi should be given an applied orientation, in consultation with the organization of commerce and industry where the students will be eventually absorbed, so that the students qualifying from our colleges/universities are adequately trained to meet the demands of industry and commerce. In this connection, the universities should introduce compulsory internship-programmes involving practical training experience for the B.Sc. (Hons.) and M.A./M.Sc. students, for 4 to 6 weeks, during summer vacations in industrial/commercial establishments, in order to gain practical experience. (ii) The existing syllabi should be critically reviewed by external experts and updated, once every three years, to ensure that recent development are incorporated and the national needs regarding manpower training are appropriately reflected.

**Education Geared to National Needs:** At present, the education imparted at various levels within Pakistan is not geared to national needs and, when we consider the prevailing standards in our schools, colleges and universities, the little education that we do formally impart is largely wasted because of the poor quality of teachers, inappropriate curricula, which have no bearing to national needs or national development plans, totally archaic examination system which tests the memory rather than the understanding and application of principles (and allows massive use of unfair means), and poor laboratory/library facilities. There has been no clear-headed thinking on qualifying the needs for educated manpower in various fields by the year 2010 and beyond. At present, we have an abundance of graduates and M.A.s./M.Sc.s in certain disciplines, but and acute shortage in others, particularly in scientific and technical fields, which is creating massive unemployment, as well as wastage of talent and national resources. There is therefore urgent need to dovetail the educational programmes with national
development plans in such sectors as agriculture, industry, health, etc., to ensure optimum utilization of our educated manpower. The admissions to colleges and universities should therefore be controlled under an overall short-term and long-term plan drawn up by a committee, with representatives from various fields in various sectors according to the projected development plans.

Moreover, while primary and secondary education should be compulsory for all, college and university education should be highly selective, so that only the most talented are allowed higher education. Vocational and technical disciplines, such as electronics, refrigeration, carpentry, motor mechanics, etc., should be made compulsory at matriculation and intermediate college levels, so that persons passing out after matric or intermediate are capable of earning their living. A large number of such vocational colleges need to be set up and students encouraged to join them instead of going to University. Many high-level postgraduate centres of scientific research and development also need to be established in key areas of science and technology.

**Improvement in Quality of Teaching Staff:** A serious vacuum of Ph.D level manpower will develop during the next 5-10 years with the retirement of many highly qualified teachers. The relevant Ministry should prepare a PC-1 form for Ph.D. level training of the younger faculty-members in foreign universities, after an assessment of the vacancies that will be created by the retirement of senior personnel in each university. At least 200 Ph.D level scholarships in areas of national priority should be arranged per year, till such time that the Ph.D level programmes within our universities have been sufficiently strengthened to meet the national Ph.D level manpower requirement.

**Improvements in the Examination System and Educational Environment for Students:** At present there is a great degree of variability in the quality of B.A/B.Sc level education provided to the students. It is proposed that a uniform country-wide syllabus should be prepared, incorporating the minimum requirements in various subjects. A centralized examination-system should be introduced, whereby question papers are set by an independent Examining Body and the university teachers are not involved in examining their own class students, as is presently the case in
many universities. It is further proposed that the examination papers for the last three years, along with the syllabi, should be submitted to international experts in the field, to critically evaluate the same and to suggest improvements. The services of the British Council, the Association of Commonwealth Universities and other international agencies may be utilized for the purpose. The question papers set in our universities at various levels during the last 3 years should be assessed by foreign experts, to independently evaluate their standards and international compatibility, and to point out the weakness for further improvement.

3. SCIENCE MANAGERS AND THEIR INITIATIVES

Science Manager play a significant role in the formulation of the S&T policy and its implementation. On their vision and wisdom depend the contents of the policy and successful implementation of the policy recommendations.

Many developing countries have good scientists, but few good managers. Administrators of S&T establishments must possess not only technological competence and administrative skills, but also a clear vision and keen awareness of the larger aims of society and its capacity to respond to rapid change. There is an urgent need to institutionalize the training of S&T managers, through in-service and pre-service courses in policy-planning, research-programming and institutional/project management. Further it is no longer possible that a scientist can achieve significant results of immediate applicability, rather it is the teamwork and multi-disciplinary approach that make major possible break-throughs in the scientific fields. In the final analysis, it is not the individual scientists but the group of scientists that matters. Group leader/manager thus plays a highly significant role in project-formulation, preparation of the S&T Plan, seeking approval and its implementation and monitoring.

More than once it has been concluded that it is not so much the funds, equipment and core of scientists and engineers, but the science manager/director which matter in the final output of the work. Scientists of international repute and prestige have convinced the political leadership and financial wizards, in specific cases, of the need for establishing a particular institute of national significance but, after its approval, it is the good manager who takes the responsibility of its successful operation. It is also relevant to mention that, in Pakistan, beside other
factors, the Paucity of science-managers was mainly responsible for long delay in obtaining final approval of the National Science and Technology Policy.

For the proper development of S&T activity in any country, it is essential that there should be a strong and energetic base of highly-trained and motivated S&T manpower in the various thrust-areas in which rapid action is anticipated. Even those who do not accept the need of having an indigenous scientific community per se, nevertheless accept the fact that access to technology is a matter of survival for all countries. This can partly be achieved through the process of transfer of technology, for which an essential condition is the participation of adequately trained scientists, engineers and technicians. Transfer of technology without indigenous S&T manpower is a fruitless exercise, as many developing countries have realized after years of wasteful effort.

Shortage of S&T manpower is thus the main impediment to the rapid development of a country. Manpower-development is a long-term proposition; it requires several decades of planned efforts.

4. SOME FUTURE MANPOWER PROJECTIONS FOR PAKISTAN

Pakistan is a typical Third-World country, with G.D.P around $500. UNESCO-Castasia Reports of 1968 and 1971 suggest a figure of about 2,000 to 3,000 per million population (and considerably higher growth-rates of 15% to 20% p.a.) for S&T manpower in developing countries with per capita G.N.P close to $500, if they are to show a satisfactory socio-economic growth. Taking Pakistan’s per capita GNP in 1986-87 as $450, this would mean about 250,000 high-level S&T manpower for Pakistan, out of which at least 10% i.e., 25,000 should be engaged in R&D (as against the present more or less static figure of about 10,000). The situation in the Universities is particularly alarming because there is not enough motivated high-level manpower to form viable research groups, of which there are hardly a dozen in the whole country at present. It is thus immediately necessary to inject 800,000 technicians into that stock of manpower, as well as 15,000 high-level researchers for the R&D system in Pakistan; a tall order indeed!

So, let us see how this development of S&T manpower can be accomplished in the shortest possible time-span. First, some “first-order guess” at the numbers that should be trained each year, hearing in mind that most other countries are
expanding their S&T manpower at 10% p.a. Since it takes 2-3 years to train a researcher as well as a technician, the following Table-4.1 indicates what needs to be done in order to bring the Country at the level of the rest of the Muslim world by 2,010 A.D. when our requirements would have nearly doubled.

### Table 4.1: Projection of Numbers to be trained, year by year, from 2008 upto 2,015 A.D

<table>
<thead>
<tr>
<th>Year</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>Total for 10 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-level R &amp; D</td>
<td>600</td>
<td>1,000</td>
<td>1,600</td>
<td>2,000</td>
<td>2,500</td>
<td>3,000</td>
<td>4,000</td>
<td>5,000</td>
<td>6,000</td>
<td>8,000</td>
<td>34,000</td>
</tr>
<tr>
<td>Technicians (Thousands)</td>
<td>30</td>
<td>40</td>
<td>60</td>
<td>80</td>
<td>100</td>
<td>150</td>
<td>200</td>
<td>250</td>
<td>300</td>
<td>350</td>
<td>1,600</td>
</tr>
</tbody>
</table>

Note: Upto 2010, we should train mostly by sending abroad, and thereafter gradually shift to local Ph.D/M.Phil, after the viable research groups have developed at out Universities.

Side by side with this massive training programme, a phased plan of R&D and advanced technology be introduced into industry, agriculture, defence and other vital sectors that form the base of the country’s development. Such a plan is imperative, and it must be an ambitious one, to fulfill the visions that were given by the founders of Pakistan. The examples are there of Japan, Korea and other countries who have achieved phenomenal progress by integrating R&D with industry and technology, right from the start, even when they were ostensibly copying European and American goods.

Knowing that Industry should consume at least as much high-level R&D manpower as these institutions, we can estimate that another 15,000 should be for Industry, thus giving us a grand-total of over 30,000 Ph.D/M.Phils. to be trained and provided by the year 2015 A.D., which is still slightly less than the 25,000 estimated from the UNESCO criterion above.

**Sub-professional S&T Manpower:** Using the Sub-professional to Professional ratio of the order of 4:1, it is estimated that at least 100,000 sub-professionals are required to assist in the R&D programmes in Pakistan. This requirement may go up to 450,000 by the year 2015 A.D. Existing 28 Polytechnics and 6 monotechnics have a combined capacity of training about 17,500 sub-professionals in
diploma courses and 17,000 in B.Tech. Courses. There is a further increase in these institutions under a regular National Vocational expansion programme. The PCSIR, in collaboration with Swiss Foundation for Technical Assistance, established Pak-Swiss Training Centre at Karachi in 1965 and, so far, over 700 technicians have been produced in advanced technologies viz. precision mechanics, industrial electronics, optics, die and mould technology. Other developing countries should seek assistance of Swiss government in establishing such institutions.

5. THE ROLE OF WOMEN IN S&T

Today, it is good to observe that the role of women is no longer confined to teaching, nursing, laboratory technicians and petty jobs in government offices, but quite a few have taken up newer technologies and disciplines, like information technology, banking, business administration, biotechnology and scientific professions. This needs to be encouraged by provision of appropriate scholarships and women’s universities in the third world countries, where possible.

A professional woman has to strike a balance between her professional role and being an important member of the family. She is not only a bread-earner, but also has a vital role in home management and imparting quality-education to the children. Being educated, more expectations are raised that children should not only be well behaved, properly educated and well trained in social and religious norms, but also should give better performance in class/group.

With the increasing demand that more and more women should be engaged at all levels of education (primary, secondary college and university), computers and software programming, pharmaceuticals, scientific research, etc., it is also necessary that the general public should be encouraged to change their attitude and accommodate women to perform their effective role in the process of economic development and industrialization, alongside their important role of homemaker.

6. MEASURES TO DEVELOP HIGH-LEVEL MANPOWER

In the Report on Higher Education and Scientific Research for Development in Pakistan (1990), the World Bank recommended that the immediate objective for change in higher educational system should be to achieve a major improvement
in quality and efficiency, so that the system can extend in response to growing national development. It proposed the areas of action pertaining to (i) a clear specialization of universities and colleges by level, so that each can concentrate efficiently the proper resources on its primary mandate, (ii) ensure the autonomy of both universities and degree colleges, and (iii) increase private-sector provision to higher education. The report acted as a catalyst in re-organization of higher education in Pakistan, involvement of private sector in university education and increasing the emphasis on linkages of university with industry and R&D institutes. One of the major objectives of training high-level S&T manpower should be its absorption by industry.

Another report “High level S&T Manpower – its training and utilization’ prepared by the Pakistan Academy of Sciences in 1990-91 observed that the absolute quantum of trained S&T Manpower is hardly one half of what it should be: the abysmally low R&D manpower, which has remained static at about 7,000 since 1975. There is a strong need not only to provide adequate training facilities for high-level manpower should be doubled every five or six years. To permeate R&D activities in every economic sector, a deliberate creation of job-opportunities in government and industry for S&T Manpower of 5,000 to 20,000 per annum should be initiated. Attractive incentives and career-structure be adopted to attract talented persons towards science and technology. (An Action Plan for additional in-take of about 20,000 M.Phil/Ph.D into R&D over the next 20 years was recommended in 1990). A Standing Committee was also proposed for monitoring the overall quality and quantity of production of High-level S&T Manpower and its proper utilization. It is unfortunate that no attempt was made to implement the report, which could have boosted the production of high quality S&T manpower in the country.

The total number of M.Phils. graduates in 1986-87 from local universities was about 200 per annum. The Ph.D programmes have been producing barely 10-20 science Ph.Ds. annually, including agriculture, in the country. In the last 50 years, Pakistan has produced about 500 Ph.Ds., which is grossly inadequate for the country’s needs. These institutions and university science departments need to be strengthened, by creating a critical mass of professors/researchers having requisite academic and scientific merit. Some efforts in this direction are described below.
The Government of Pakistan initiated its Central Overseas Training Scholarship Scheme in 1964 for training of University and Professional College Teachers, alongwith scholarships that were offered by friendly countries. So, an S&T Manpower Development Programme of significant dimensions has to be based on national resources. Anticipating the requirements of highly trained manpower in new and emerging technologies, the Government of Pakistan launched the Human Resource Development Programme, with the objectives to:

- Create a critical mass of highly qualified S&T manpower in new and emerging technologies;
- Improve the R&D potential of the research institutions and training-potential of the universities; and
- Provide highly trained manpower for the industrial sector (public as well as private sector).

This was the largest S&T manpower training programme ever launched by the Government during the 20th century. It envisaged the training of 1,631 young scientists, engineers and doctors over a 10-year period by post-graduate studies leading to M.Sc. and Ph.D. degrees in advanced science and engineering fields. The requirements in different subjects were based on the manpower surveys conducted by the Ministry of Science and Technology.

The HRD Programme was implemented in several phases. About 1100 scientists, engineers and doctors were sent to pursue their studies, mostly in the U.S.A and U.K. Besides, some scholars are engaged in post-graduate studies at the selected science and engineering departments of the local universities where research and instruction facilities for Ph.D. degree are available. Most scholars had returned after completion of their studies and the majority are employed in universities, R&D institutions and public/private sector organizations and industries.

**HEC’s Scholarship Programs:**

The Higher Education Commission during 2005-06 has initiated several programs for faculty development in public and private sector universities and degree awarding institutions plus award of scholarships to the talented students for post-graduate studies leading to M.S. and Ph.D. degrees within the country and in foreign universities of repute. The HEC was established on September 11, 2002
under the Presidential Ordinance, replacing the University Grants Commission which was operating under an act of the Parliament since 1974. The HEC faced major issues in regard to poor standard of faculty, low enrollment of higher education, minimal relevance of higher education to national needs, low quality of research and poor governance of universities. To overcome the situation, the HEC launched the Medium Term Development Framework (2005-10) with strategic aims of faculty development, improving access to higher education, promoting excellence in learning and research and its relevance to the national needs. Several programs have been launched to enhance faculty development.

The institute of higher learning is distinguished by the quality of its faculty, presently very low in Pakistan. About 25% of the current faculty members hold Ph.D degree and less than 25% of the faculty is engaged in research. The major thrust of faculty development involves scholarship programs for increasing Ph.D faculty base, in-service training, attracting talented young graduates towards teaching and research and provision of enhanced facilities for Ph.D qualified faculty to ensures that they have an intellectually stimulating academic career. Some relevant programs for this five-year period, are mentioned below:

- Ph.D Fellowship for 5000 Scholars (Indigenous), with provision of monthly Stipend of Rs.8000; Rs.100,000 per year to the university department for equipment, chemicals, etc. in reference to research work and Rs.5000 per month to the supervisor. The fellowship is of four-year duration.

- 15,000 to 20,000 persons will be sent abroad for Ph.D in suitable foreign institutions in fields of national priority over the next five years. Each scholarship is of 4-year duration with maintenance allowance of $800 per month plus university tuition fee, book allowance and air travel. The scholarships are offered for perusing studies in selected universities in Austria, China, France, Germany, U.K., and USA, etc.

- Split-Phd. Program: The program is aimed at increasing international linkages in the priority subject areas. Two models are followed:- (I) first two years at local university, two years abroad, degree is awarded by the foreign university and (II) first year in Pakistan, two years in foreign university and fourth year in Pakistan for thesis work and degree is awarded by the local university. All expenses are paid by the HEC.
Post-Doctoral Fellowship Program: 1200 fellowships to faculty working in public sector universities and institutions (80%) and 20% to the faculty engaged in private sector and degree awarding institutions. Each fellowship is of 9-12 months duration with monthly stipend of $1200 plus economy air ticket. A bench fee waiver may be obtained.

These programs have attracted numerous talented students and faculty members to enroll for the post-graduate studies in local universities. This is evident from the following figures in the Statistical Yearbook on Higher Education (HEC, 2005):

In 111 universities and degree-awarding institutions, the enrollment at M.Phil level has doubled from 3,871 to 7,454 and similarly for Ph.D. level from 3,124 to 6,472 between the year 2001-02 to 2003-04. In contrast, some years back just 12 Ph.Ds and over 150 M.Phils were being produced annually by the local universities. Even allowing for normal attrition by students getting good jobs and leaving during the M.Phil/Ph.D program, this is indicative of a substantial increase in high-level S&T Manpower during the next five years – a step towards the rough projections made.

However, the implementation and programming of these institutions require careful management and periodical review, in order to obtain optimum benefits and prevent misuse.

Wealth from Knowledge: There is a basic change in the orientation of Scientific communities from that based on ‘advancing knowledge’ to that involved with ‘creation of wealth’; this is an important ‘ideological shift’. There is also a corresponding shift of emphasis from ‘basic research’ to ‘technological innovation’ and, in the last 2 decades, much of this new inspiration is spreading across the rest of the developing world firm the experiences of East Asia.

This does not mean that countries like India have given up doing basic research or that this domain of research is unimportant. However, when it comes to selecting research-problems we can see a shift in the goal direction of research which is increasingly deemed as an investment factor. The notions of value-addition, profit, efficiency and so on, have assumed greater significance. Since the ideal of advancing knowledge is slowly but steadily being enveloped by the pragmatic value of creation of wealth, there is pressure to withhold critical elements of knowledge-production from open publications.
In the current phase of globalization, international regimes, such as intellectual property rights (IPR) under GATT (General Agreement on Tariffs and Trade), biodiversity and the penetration of MNCs in developing countries, are catalyzing this shift in the orientation of scientific communities. All major science agencies, Indian Institute of Technology (IITs) and universities have now established patent or IPR centres to facilitate and catalyse patenting.

Given the emerging culture of intellectual property rights and creation of wealth from knowledge, the norm of secrecy is no longer a taboo and this will withhold new knowledge from the public for a certain period of time, depending on the contextual situation of establishing priorities in the commercialization of knowledge. One significant change that is quite clearly visible in the operation of scientific communities is the gradual loss of their traditional research-autonomy; this is a consequence of the increasing commercialization of knowledge.

Natural-resource endowments and cheap labour are unlikely to continue to give the comparative advantage to developing countries, such as India, that they did in the past. There is little doubt that value-addition through technological change and the role of knowledge is going to play a central role in the creation of wealth and development-processes of the future. In other words, society is transforming from an agriculture and industry-based economy to a knowledge-based one.

There is a policy discourse about taking India into the new millennium by creating a “knowledge-society” through the IT industry. However, in a country where 50% of the population is still illiterate, an equal number of people still lack proper sanitation and access to safe drinking water, and average child-mortality is around 72%, the challenges underlying the role of education and literacy hardly need to be underlined. The situation calls for doubling the national education expenditure, as a percentage of GNP, in the coming years. Most importantly, human and social development indicators must acquire a central policy-concern in any discourse on creating a knowledge-society.

7. PROMOTION OF S&T IN SOCIETY

In order to ensure sustained interest of the general public in S&T, it is necessary that people are informed regularly of the advances in science and technology as well as their application: creating widespread awareness of S&T as an instrument
for improving the quality of life is one of the basic aims of the S&T policy. This is not an easy job, particularly in countries where illiteracy is as high as 75 per cent. To upgrade public awareness of importance of S&T the following programme is followed:

- increase nation-wide awareness of S&T as an instrument of social and economic change
- increase national consciousness of real impacts of S&T in the country
- Some concrete measures to implement this include:
  - Utilization of mass media for public awareness of science and technology
  - Publication of Science and Technology literature
  - Science and Technology Centres, Clubs, Museums and Planetaria
  - Demonstration of improved technologies in rural areas, and
  - Strengthening of Non-Governmental Organization for Science and Technology.

Korea has launched a ‘Movement for the popularization of S&T as an integral part of its long-range development plan. The movement aims at accomplishing a universal desire for scientific innovation among all the people in all aspects of their lives. It has been led by the Ministry of Science and Technology, the Science Promotion Foundation and the Saemud Technical Service Corps, in cooperation with concerned government agencies, academic circles and the mass communication media. The basic goal of this movement is a re-orientation of the public’s attitude towards S&T.

In Pakistan, the Pakistan Science Foundation was established in 1973 to promote and finance scientific activities having a bearing on the socio-economic needs of the country. It promotes science awareness in the country through various activities, such as establishment of Science Centres, Science Clubs, Museums, Herbaria, Plantaria, and arranging Mobile Science Exhibitions/Fairs, Science-film shows, Popular Science Lectures, Summer Schools and providing popular science magazines to schools and grant-in-aid to the NGOs. Non-government scientific societies, associations and learned bodies and private science foundations play a vital role in disseminating scientific knowledge and promoting science through meetings and scientific publications. The Indian Science Congress (1914) and the Indian Academy of Sciences (1934) played a significant role in promoting S&T in society and also in
bringing S&T policy issues at the doorstep of the highest echelons in the Indian government.

The people should be kept regularly informed of the advances in science and technology as well as their applications, so as to mobilize them to innovate, adopt and apply such knowledge in practical fields.

To popularize S&T at the grass-root level as one of the objectives of the S&T Policy, the following information may be collected:

- Literacy percentage, with rural and urban, male and female and various age-group literate persons
- S&T organizational structure, with information about character and functions of R&D institutes and science support services
- Number of languages spoken
- Stage of development with reference to communication and electronic media and educational system
- Survey of existing S&T information facilities and needs
- The strength and weakness of the scientific community
- Allocation of funds for S&T sector in the Five-Year / Annual Development Plan
- Linkages of R&D institutes with industry, commerce and agriculture

Science and Technology Policy cultures are conceptualized with differing development- priorities, policy instruments, ethos and respective core-constituencies relating to science, technology and development issues at the national level. The categorization of these policy-cultures can be taken as ‘universal’, in the sense that they find relevance in most of the countries or national contexts. However, they are to be understood and framed, with reference to the contextual situation.

The policy culture perspective, as applied in the Indian context, represents competing ‘paradigms’ or frameworks, which influenced and governed S&T policies and, hence, the growth of science and technology institutions during the last five decades. In an effort to understand further the contextual features of the Indian situation, it is pertinent to explore briefly each policy culture.

**Science and Society Interaction:** Society is constantly changing with the time. Rapid advancements in science and technology in one part of the world have
direct impact on the societal behaviour and outlook in a country far remote and underdeveloped. Spread of scientific knowledge through education and mass media has not significantly changed the outlook and attitude of the people living in thousands of villages of Asia. It is said that science and technology, instead of bringing about an equitable and just society, has created greater inequality among the nations on one hand and among different sections of society on the other. Is it something wrong with science or with society? In this situation, formulation of a proper S&T policy may help strike the balance. The policy must provide safeguards as well as appropriate mechanisms whereby the inputs into the society through science and technology can be translated fully into socio-economic gains, in conformity with the overall social objectives. The policy makers, scientists and agents of change must ensure that they have both the political will and public opinion in favour of science before science can take firm roots in the society.

The disenchantment over the role of modern science and technology in society was clearly evident from the emergence of the “People’s Science” and “Alternative Science” movements (including pressure from the environment and ecology groups) which came into centre stage of politics and decision-making by the early 1980s, signaling the importance of civic culture. The Bhopal Gas tragedy, which claimed more than 5,000 human lives as a result of a poisonous gas leak from a Union Carbide factory in Bhopal (the Central Indian state of Madhya Pradesh), exposed the dangerous consequences of not paying attention to R&D risk-assessment, particularly when India was transferring massive foreign technology during the preceding three decades.

At the intellectual level, both as a result of the various events which took place in India and the influence of a growing western discourse on counter-science movements, a critical stream of thinking emerged which, in varying forms, provided an underpinning to the emergence of the alternative science movements (see Krishna, 1997).

8. Political Climate in favour of Science and Technology

Creating political climate in favour of science and technology depends on several factors, most importantly leadership, educational level of the elected members of the Parliament, form of government, socio-cultural traits and the political
environment existing in specific situations. For instance, India is comparatively advanced in S&T potential and science based technologies in comparison with the majority of the Third World countries; this is due to the importance given to science and technology by the first Prime Minister Mr. Jawaharlal Nehru and subsequently followed by those who were elected to his position. His frequent meetings with scientists and technologists, giving a free hand to eminent scientists in development of research institutes/laboratories of international repute, adoption of Science Policy Statement by the Government of India, setting up a Scientific Advisory Committee to the Cabinet, and the appointment of Science Adviser to the Prime Adviser are some of the actions which also provided an opportunity to others in understanding science and technology in the context of overall science and development. His sermon was that the future belongs to those who cultivated science and befriended technologists. The educational standard of the Parliament Members has also a significant effect on the requirements of S&T Policy of a country. Those with little education and non-exposure to latest developments of science and technology may not realize the need of a national S&T Policy. With this ignorance, they may spend more energy and funds in issues concerning construction of roads, sewerage and establishing industries on imported turn key plants. The form of government gives time to hear on matters of national importance and deliberate extensively on the subject-areas which have direct impact on the socio-economic development of the country. The democratic government, as compared to autocracy or indirect form of government, follows the democratic procedures to conduct the business. In this situation, members are more assertive and vocal in debating issues which have direct impact on the economy. It is the scientific temper to get rid of intellectual backwardness of the people and to enable them to appreciate new developments and adopt them to bring about a renaissance in the country.

Low per-capita incomes (less than $500), high population growth (more than 3.0% p.a.), low literacy (about 35%) and low life-expectancy (around 57 years), in combination with the poor educational system, inadequacy of the scientific infrastructure and the age-old traditions, create strong barriers for utilizing the benefits of modern science and technology in third-world countries like Pakistan. In this context, every scientist, engineer and educated person is duly-bound to contribute to promotion of science and technology in society. This can be done through popular science lectures; active participation in science fairs/exhibitions
and scientific books and newspapers, articles, magazines and journals; programmes on T.V., radio and video films. Science programmes in national and regional languages can be more educative and effective, particularly when dealing with their applications in daily life.

The various NGOs could make substantial contributions to the process of development and to improving the quality of life of the people, because they can provide:

- a reservoir of individual scientists, engineers and technicians, with specialized knowledge and expertise, that can be mobilized to undertake specific tasks;
- a ‘peer-review’ system for evaluating the importance and value of scientific and engineering proposals, projects and accomplishment;
- an open market of planning and delivery-systems for technology;
- an important educational function, through the journals, reviews, handbooks, and books they publish on the accomplishments and advancement in their disciplines;
- a forum for information-exchanges on a wide range of topics in the scientific community.

There are four categories of Scientific Societies; (a) general societies for the promotion and popularization of science; (b) specialized societies dealing with a particular discipline of science; (c) professional societies, which look after the interests of the relevant professionals; and (d) prestigious societies, which are frequently consulted by government on problems and issues concerning science and technology, and serve as channels for dissemination of knowledge on latest advances in science and technology. These learned bodies and societies also provide a forum for members to articulate their views on the areas of their specialization, conduct examinations for professional diplomas, publish scientific and technical journals, organize conferences, seminars and symposia and, in some cases, maintain their own libraries.

**Action Plan for Promotion of Science in Society:** Promotion of science has to be an all-round activity to benefit all strata of society, including the student-community, the housewives, ordinary labourers in the factory and small farmers in the remote villages. For this purpose it is necessary that:
• The NGOs should organize science fairs and exhibitions on a regular basis at divisional and district level, in cooperation with the local R&D institutions, universities, industries and foreign-based organizations. They may follow the pattern of Pakistan Science Foundation, which is organizing Science Expo in Islamabad, at regular intervals;

• The Government should encourage senior scientists and technologists to write scientific books and monographs, in simple national languages, on national problems and their solution through application of S&T. Annual awards and cash-prizes should be bestowed on high-quality books published by the scholars and scientists;

• Science should be introduced in the syllabi of all religious institutions;

• The NGOs should critically examine their handicaps and problems; in particular, why the younger members of scientific, engineering and teaching communities are rather hesitant to joint these organizations, despite low membership-fees;

• The growth and expansion of NGOs are indicators of science and technology in a country. The science funding organizations should call an annual or twice-yearly meeting of these NGOs to coordinate their activities and for scheduling their programmes on year-to-year basis.

What is needed is an honest-to-God commitment by the people and the Government to the promotion of science at all levels and, especially, in the villages, the small towns, and backward areas, where the majority of the population still dwells. This should come, preferably, through a declaration in the Parliament.

Incentives to Scientists: Scientists and technologists are the main actors at the base of the drama of scientific development. The successful formulation of the S&T policy, its implementation, programmes and projects would depend on the competence, skill and devotion of the personnel working in scientific R&D organizations / institutions and universities, which is ultimately linked with ‘job satisfaction’. Inadequate facilities, lack of conducive environment, unsatisfactory service-conditions, poor emoluments and career prospects in R&D institutions are the main causes of the present “brain-drain” of highly qualified scientists, engineers and university teachers. It has been estimated that
the monitory value of technical expertise transferred to developed countries during the last 30 years, as a result of migration of highly skilled personnel from the developing countries, is roughly equivalent to the total aid so far received by the Third World from the developed countries. Talented scientists & technologists migrate to advanced and industrial countries, sometimes for reasons of better emoluments, but mostly due to the conducive environment that is available in those countries for creative and productive work.

Further, the local employment-opportunities in the fields of research and development are so restricted in our countries that there is no incentive for talented students to study for research degrees and, often, they prefer to go for engineering and medicine. (As a matter of fact, in the recent past, the registration for MS degree course had steadily declined in Pakistan.) Some of the measures, which Pakistan has so far taken to improve service-conditions and incentives for S&T personnel, are worth noting viz;

- An award system has been introduced to reward outstanding contributions of researchers by recognizing excellence in various branches of science, technology, engineering and medicine.
- Competent research scientists are allowed to continue to do their work and to attain the highest grade (in the government structure). Previously, scientists used to shift to administrative jobs for securing higher promotions.
- A qualification allowance of Rs.1500 per month (nearly 1/3 of the starting salary) is given to those who have a Ph.D degree.
- Research allowance, at 20% of basic salary, is allowed to those scientists and engineers who are engaged in research.
- Computer and Design allowance are given to the professional engineers working full-time on computer and engineering design.
- More opportunities are provided to improve their qualifications, within the country and abroad, through Ph.D. and post-doctoral studies.
- Efforts are being made to simplify the procedures for participation of the Pakistani scientists in the international meetings and conferences.

The recommendations of the UNESCO-CASTASIA are that a growth-rate of 15% to 20% per annum in S&T manpower could be sustainable in developing
countries. This clearly indicates the feasibility of fulfilling the requirement to double our educational and training facilities for S&T manpower every five or six years. This requires deliberate creation of appropriate job-opportunities in Government and in Industry for S&T manpower on a confining basis. Simple lip-service to Science & Technology would no longer suffice. Another thing to remember is that “mediocrity breeds mediocrity” and, therefore, a concerted effort would have to be made to ensure that (a) productive scientists of proven caliber are placed in professional and other responsible positions in the Universities, to man post-graduate departments and centres of excellence, as well as in Industry, and (b) a chain of well-equipped technician-training institutions is developed to provide technicians to support the various R&D activities. Some proposed incentives are:

• Attractive career-structure for scientists/technologists in research & teaching, comparable with that in the administrative service and comparable with industry; in the long run 50% of these should work in industry and 50% in education and R&D;

• Adequate recognition of meritorious Scientific and Technological achievements, through awards, accelerated promotion, etc., preferably based on objective evaluation of the work;

• Possibility of promotion to the highest managerial grades while continuing in the laboratory or other research/technical work;

• Better-equipped laboratories and improved working conditions, to attract talented scientists.

• Yadav in his study on Agricultural Research in Nepal pointed out that the Researchers cite low salary, absence of job description, low accountability and poor training-guidance, supervision and evaluation as causes of low motivation. Their productivity is affected by lack of proper research-plans and programmes, inadequate financial and administrative authority, lack of facilities for publication of research results, poor libraries, temporary appointments, and long delays in promotion. He recommended that improved management could provide the clear focus and direction that are needed to develop a strong and effective research system. This situation prevails in the majority of the Third World countries.
The Brain Drain: Because of the universality of science it is, relatively speaking, very easy for scientists to perform their scientific work in any country around the world, even if it is not their native land and the people do not speak their (native) language. As a result, there are a substantial number of scientists who have “brain-drained” away from their native countries and work in other countries. In the case of Islamic scientists, this migration is often to a non-Islamic country. In addition, there is also a significant amount of “internal brain-drain” within the Islamic world, mainly to the oil-rich Arab countries.

It is sometimes automatically assumed that the only motive force in the brain drain is money; that is, the salaries offered to scientists. This is a gross misperception of the situation. Whereas salaries do play some role in the brain-drain, there are numerous examples of scientists choosing locales with lower salaries, because various other factors pertaining to the performance of scientific work were favourable. An eloquent example is South Korea, which has succeeded, over the past two decades, to reattract from abroad a number of senior scientists even though the salaries offered were below those obtainable abroad.

Among the factors important to a scientist in deciding on the locale for scientific work are:

- A favourable research environment, relative to the resources of the country. This includes opportunities for communication with other scientists and a minimum of bureaucracy in handling the logistic aspects of research.
- Recognition on the part of decision-makers in the country and by the society of the country, as a whole.
- Salaries that are generous, relative to the average salary-structure of that country.

There are also measures that can be taken during the time when the budding scientist is receiving advanced education abroad. The home scientific community should maintain contact with such students abroad and, possibly, offer them scientific employment at home during long vacation periods. In addition, it is essential that such students, while abroad, receive some auxiliary education in those contextual aspects of doing science which are needed for a practicing scientist in a developing country.
Science for the man on the street: One of the three main motivations for doing science is that it is a major influence on Man’s view of the world and of Man’s place in the world. This attitudinal effect of science, this influence of science as a cultural factor, should be aimed not only at scientist-specialists, but at everybody in the country. Quite apart from the factual knowledge that science has generated, science has certain attitudinal traits, certain philosophical and methodological underpinnings, certain assumptions which apply to the life of everybody. Notably, that knowledge is open; that with new knowledge, Man’s fate can be influenced; that change is a basic element of life; that comparison with reality is a powerful way of judging ideas and activities, are beliefs that are inseparable from any concept of development and hence promote the attainment of development. Thus, science as a cultural force is of utmost important to a country in the 21st century in ways that go far beyond the direct material effects of science.

In the majority of developing countries, in which doing science is an activity of very recent vintage, only the scientists themselves can be counted on to radiate the cultural and attitudinal effects of science over the whole country. This involves working through the public communications media (newspapers, radio, television), through exhibits and museums, through schools and informal educational opportunities. The emphasis should not be to assure that 60% of the population can recite Newton’s three laws; that, even if achieved, would contribute nothing. The emphasis must be on the attitudinal and cultural effects of science; that is, on science as a fruitful human activity.

9. ADMINISTRATION OF S&T

(a) Continuing Education for Scientists:

Scientific knowledge doubles every decade or so: new areas of research spring up, once important problem areas become obsolete and uninteresting – science is in a state of constant and rapid change. Thus a young scientist who just received his Ph.D in the best scientific center of the world, and has written a brilliant thesis, can look forward to a complete loss of his scientific potential in 10-15 years or even earlier unless he constantly spends a significant amount of effort to maintain his currency in science, to learn about new developments, to interact with people responsible for new results in the various scientific areas. Being
constantly refreshed and current in scientific developments is of particular importance for the function of a scientist as a funnel of scientific information into the country. The most important role of a scientist in a developing country is not his personal research, but his ability to form the link between the new scientific development around the world and his own country. Major portion of the science the country needs for its own developmental purposes is generated abroad and is, in most cases, freely available but needs somebody in the country who can assess it, select among it, receive it, interpret it, and transmit it to those in the county who need it. In this role, the scientist very much needs to be up-to-date on scientific developments around the world.

A necessary condition of filling such a role successfully, of course, is being personally engaged in some research work, because it is through the communication within the worldwide research community that such an ability to be up-to-date is acquired. But doing research personally is not a sufficient condition. There must also be explicit opportunities for scientists to maintain their “continuing education.” Workshops, seminars, conferences, visits, journals, preprints, and other modes of communication all contribute significantly to this.

**Short-term Training Visits for Scientists and Technicians:** The government should, therefore, provide grants for short-term training visits abroad of university teachers, scientists and technicians in specific fields of national need. The period of such training should be 3-12 months and the grant should cover air fares, accommodation expenses and training fee. It is essential to introduce measures to encourage interaction with institutions in the West, if we are to acquire new technologies. At present, the governments have mostly adopted a closed-door policy. For instance, organizations such as Pakistan Science Foundation and University Grants Commission do approve grants for participation in international science conferences/workshops, etc., but these grants are made conditional to the production of N.O.C. from various Ministries. The government does issue such N.O.Cs, but lays down a condition in them that they will be valid only if no government funding agency is involved. Thus a scientist is caught in the strange-hold of such rules, and he is unable to participate in conferences abroad, even when he has an N.O.C from the government and the approval of a travel-grant from a national funding agency, because of such bureaucratic idiosyncrasies.
(b) **Heading of Science Institutes by working Eminent Scientists:**

Lastly, but most important of all, our science institutions must be headed by eminent active scientists who have been productively involved in “frontier research”, as proved by their research publications in top international journals during the last 5 years. At present our institutions are plagued with the curse of “science administration” – a concept which just does not exist in any top Western Institutes. Seniority of service, without corresponding research, must count negatively in science, and the conventional bureaucratic lines of thought must be abandoned if our science institutions are to flourish. “Seniority” in science depends solely on the research output, as shown by high-quality publications in international journals. We must apply the same standards which are the norm in the West to our institutions and transfer “senior” non-productive “science managers” to Ministry or other desk-jobs, so that our science institutions are headed by dynamic and active working scientists.

Unless this is done, all financial inputs are likely to be wasted, as the majority of heads of our science institutions have been out of touch with active research for decades and are now totally unfit to run our research institutions. Dynamic leadership of active scientists is mandatory if our science institutions are to flourish.

(c) **Incorporating interests, accountability, reward:**

The loss of research autonomy is not unrelated to the incorporation of various external interests by the scientific communities in their research programmes, coming from the government, industry, political parties, and various social groups and movements. Globalization has catalysed the influence of industrial and trade-related interest-groups and their communities in the S&T decision-making systems at the top level of government, which was earlier dominated by elite scientists and technocrats.

However, the new agencies, which have also come to centre stage of politics and society in the last decade and which are influencing the research agendas in many areas of science, are the social interest groups and social movements in ecology and the environment. The increasing manifestation of these interests, among other aspects, is at the heart of the transformation of the social institution of science. One important consequence is that the scientists are subjected to the scrutiny of, and accountability to, a number of interests groups including their scientific peers.
With the increasing importance of intellectual property rights, there is an increasing trend towards patenting, designing, software and so on, compared to the earlier emphasis on open publications. The number of open publications is likely to gradually decline in the coming years because of the increasing trends towards consultancy and sponsorship-based research programmes in academic and non-academic research settings. A recent study by Raghuram and Madhvi (1999) which surveyed the pre and post-reform period form 1981 to 1995 revealed that India’s share of world output in science publications during this period witnessed a sharp decline of 35%. India ranked eighth in the world in 1981; this declined to 13th in 1995. Full-time research and academic institutions are beginning to open up and revise the existing reward-structures so as to be commensurate with the changing manifestations of economic and market interests.

(d) Management of R&D and entrepreneurial mode:

Liberal economic policies under globalization, which led to the expansion of the private sector in education and high and new-technology areas have fostered ‘two cultures’ of private science’ and ‘public science’ with distinct work-cultures, salary levels, incentives and other perks which have created institutional and management problems for research institutions. As the head of CSIR in India (which maintains over 40 national laboratories and where over 10,000 scientific and technical personnel work) commented recently:

“The emergence of R&D centres in India by multinationals needs to be viewed in a perspective also. With super attractive remunerations, world-class facilities and cutting-edge and challenging problems, many top brains from the S&T community will be attracted by these centres. It is absolutely essential that the Indian R&D institutes urgently create an intellectually stimulating environment, where young minds could be challenged and performers could be awarded handsomely.”

Science agencies and universities in India are undergoing a transformation, mainly to incorporate an entrepreneurial mode of work and culture. For instance, as the vision document of CSIR observes, “the entrepreneur in a scientist would be awakened, equipped and motivated to venture out in knowledge-market space”. Different manifestations of this new trend are discernible: from promoting industrial and private
consultancy and corporate industrial investment, and bringing universities closer to industrial needs and demands, to the creation of new firms by professionals, both from the university and non-academic research laboratories.

We can now speak of a new ‘community’ called ‘professional entrepreneurs’ in India who have opened up companies and firms mainly in new and high technologies, such as software, computing and information technologies, telecommunications, biotechnology, horticulture and floriculture. What is important is the shift in the traditional academic ethos and values in the 1990s, which happened in the USA from the beginning of the 1980s.
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1. INTRODUCTION

Scientific research, basic as well applied, calls for heavy investment of capital and human resources, particularly in new and emerging technologies, and it becomes difficult for a single country to mobilize the resources on the required scale. Even the most developed countries have S&T agreements for cooperative research, so as to reach a high level of collective self-reliance through mutual cooperation and sharing of expertise, experience and knowledge. Regional S&T cooperation is beneficial to all the participating countries. S&T cooperation may be required in four broad areas:

- building-up and strengthening of S&T institutions
- training and education;
- exchange of knowledge, know-how; and
- cooperative S&T programmes.

The bilateral S&T agreement is the main vehicle for cooperation sought in the above-mentioned broad areas, particularly in areas of training, higher education, exchange visits, networks of cooperating institutions, joint purchase of technology. In addition, the regional and international S&T cooperation, through promotion of regional groups/international organizations and private foundations, is increasing day by day for improving S&T capability for sustainable development.
Quest is a part of human nature and this thirst to discover has in fact turned into science. It does not limit itself to any geographical boundaries or political and ideological barriers across the globe. Scientists’ interaction has increased among countries of South and North, through scientific meetings, seminars, books and journals; and “internet” has now brought them much closer. The increasing conscientiousness of problems common to these people, globally, has brought about a sharper awareness of the mechanisms, and relevant institutions have now been developed for the purpose from S&T agreements among nations of the world, under UN umbrella and otherwise. Science and Technology is a source of power, wealth & prosperity. Nations are in competition with each other to acquire technology for industrial growth and defense. Science and technology available at the international market cannot be shared by all countries, due to geographical and political reasons, and it has to be attained indigenously especially to build up local regions and international capacities for socio-economic uplift – specifically for 2 billion people living below the poverty-line. S&T transfer has, consequently, become a critical area of foreign policy and there is selective sharing based on geo-political and ideological orientation.

International cooperation, both south-south and north-south is imperative for strengthening S&T applications for socio-economical development in the developing states. Sharing of human resources, using capacity building and technology transfer, is the basic foundation for S&T development in any developing country. In addition, sustainable HRD is another factor for promoting sustainable development and for stopping brain drain. This includes valuable technical manpower, expertise and institution-building through advanced training, indigenous and advanced joint research, scientific infrastructure and adequate literature. Many governments have entered into bilateral agreements. International and Regional Agencies are playing a critical role in facilitating such international cooperation, for example COMSTEC, COMSATS, ISESCO, ICTP, TWEAS, South Center, UNIDO, UNDP, UNESCO, to mention a few.

Such co-operations are highly beneficial and need to be pro-actively pursued in, and across, continents of the globe, in order to improve the quality of life and remove discrimination disparity and diminish the digital divide or knowledge-
divide between nations. In the larger perspective of developing countries, liaisons and linkage/networking would have to be established between the following major groups:

- South-South Cooperation (Developing Countries);
- North-South Cooperation (Linkage between developed world and developing states);
- UN specialized Agencies;
- International and Intergovernmental Agencies.

In the light of the above, it is imperative to have Integrated S&T policy on nationwide level, incorporating and networking with regional and international cooperation as an effective instrument for strengthening S&T potential. This can be achieved through the following measures:-

- Promotion of collaborative R&D programs, through closer linkages between national and international research establishments;
- Enhanced emphasis on bilateral and multilateral agreements for cooperation in S&T fields;
- Simplification of procedures for planned study-visits and liberal participation of scientists and technologists in international conferences, symposia, workshops and seminars;
- Appointments of Science Attaches in Embassies in countries like USA, UK, France, Japan, China, USSR and in other developing countries for South-South Cooperation;
- Direct linkages should be established between the R&D organizations of developing and developed countries, through sisterhood relationship for institution-building and joint research programs;
- Active co-operation should be established between the developing countries; acquisition of know-how on a collective basis from advanced nations for similar projects in more than one developing country may be considered, to enable a better choice of technology, reduce costs and secure contractual terms;
- Active-co-operation with other developing countries in building up S&T capability and research programs sponsored by various international agencies.
a) Linkages between R&D Institute-University-Industry

University, R&D Institute and Industry are the main pillars of S&T cooperation among the countries, albeit with appropriate level of trained manpower. Appropriate utilization of limited R&D facilities, funds and manpower has been in sharp focus at deliberations in the developing countries. The need to conduct research and to invest the limited resources on it is often questioned by the financial experts on the plea that there is no demand for research; that the industrialists do not approach the scientists in solving their industrial problems, nor they have faith in the innovations and products developed by the scientists in the local R&D laboratory. Furthermore, in the majority of universities there is no tradition for research and technology development, and basic research is conducted which has no relevance to the needs and requirements of the end users and is incapable of solving national problems. It is further noted that the scientists live in ivory towers, cut off from the subnormal conditions of the people living in the lower strata of the society and those living in the remote and inaccessible areas; that the industrialists can call the foreign experts to remove the hurdles on the turn-key projects, with the understanding that the technology can be purchased at any cost from the foreign suppliers. Under this divergent situation, the three pillars of science and technology policy (R&D institute, university and industry) stand on weak foundations.

Keeping in view the limitations of scientists and engineers working in the laboratories and the colossal cost-component involved in taking laboratory research results to pilot-plant scale, many countries have established Research and Development Corporations to serve as an important link between research and industry. The corporation’s main objectives comprise (a) commercialization of know-how developed in various research institutions (b) promotion of inventive talent in the country through awards and financial aid, (c) bridging technological gaps by promoting developmental projects, in collaboration with industry; and (d) technology transfer and marketability.

Linkages between R&D institute, university and industry are manifest in several forms, like contract research, consultancy, exchange of personnel, utilization of research-facilities by industry, testing of materials and use of specialized equipment and facilities of industry by laboratories. It is important that scientists and engineers should visit the industrial units to know their problems and assist
in improvement of quality, efficiency of operation and in upgradation of
technology. In the future, R&D institutes should be established in proximity to
the end-users. The constant interactions between university teachers, laboratory
scientists and industrial entrepreneurs may help to solve many problems and
considerably reduce the reliance on foreign expertise and technology. It is also
important that the fiscal and trade policies should encourage development and
adaptation of indigenous technology, a step forward towards self-reliance. At
national level, institutional arrangements should take on the task, whereas
regional and international joint projects should be initiated, involving relevant
institutions, to build up capacities as well as address local issues.

(b) Trained S&T Manpower:

The serious lack of talented and well trained scientific workers is today the major
weakness of the S&T sector in the developing countries, which must be
overcome with utmost speed if full benefits from the investments in scientific
research and development are to be reaped. Modern science requires extensive
facilities and an environment of excitement, urgency and challenge for its
progress. The human resource development programme should be arranged in
such a way that the present and future requirements of the R&D institutes,
universities and industries are met according to the R&D needs of the specific
country. Mushroom growth of R&D institutes without a critical mass of highly
trained manpower will not give fruitful results. There are many institutes which
are manned by 4-8 scientists having Ph.D qualification, whereas each of these
institutes (electronics, biotechnology, renewable energy) should have atleast 30-
40 Ph.Ds with double the number of M.Sc/M.Phil.

The present stock of S&T manpower in India is in the region of 2.5 million (or 3
per 1000 population), the third largest in the world, next to USA and USSR. Beside
meeting its requirements, thousand of qualified scientific workers are working
abroad. In Korea, with the process of industrialization diversified in heavy and
chemical industries in 1970s, the Korea Advanced Institute of Science and
Technology (KAIST) was founded as a postgraduate school in science and
contributed to the establishment of a mass supply-system of high-quality scientists
and engineers. Also, there was significant expansion of education at all levels.
Besides improving the quality and quantity of science education in schools, colleges and universities, the number of sub-professional manpower has to be increased considerably in near future. The UNESCO – CASTASIA model had laid down that the rate of sub-professional to professional S&T manpower should be of the order 4:1. This is because high-level S&T manpower cannot perform effectively unless proper back-up services, are provided by sub-professional manpower, and this includes para-engineering, para-medical and para-scientific staff as well as skilled craftsmen, who will have to be increased manifold. Each country should develop a long-term science and technology plan for next 20 years, which should have the basic component of manpower development of various categories.

The following information should be available to anticipate the requirements of S&T manpower for implementation of the S&T policy, in conjunction with the development plan:

- details of programmes and projects of the development plan;
- present position of various categories of scientists and engineers and sub-professionals in R&D institutions, extension and development organizations;
- present vacancies and future requirements according to scientific disciplines;
- the present enrolment in science and engineering departments of the colleges and universities;
- their annual output;
- future programmes of expansion and establishing new departments and institutes and their manpower needs;
- availability of training facilities through private foundations and international agencies;
- survey of scientists, engineers, doctors and technicians working abroad and their indication of return year-wise;
- identification of new and emerging technologies where training is required and where facilities are not available;
- projections of requirements of S&T manpower for next 10 and 20 years;
- balancing of supply and demand of scientists, engineers and technicians.
Experience gained in China, India and South Korea indicate that qualified, S&T Manpower is not only required for the local R&D institute, university and industry to improve their capability and experience, avail and utilize the existing knowledge and technology effectively, and efficiently but also to take full advantage of existing facilities at the international institutes.

3. CASE STUDY OF KOREA’S EXPERIENCE OF INTERNATIONAL COOPERATION

Despite geo-political and geo-economic disadvantages, Korea has been able to transform itself into a global player in S&T, within a short period of time, using international cooperation for economic development by building capacity, acquiring technology and catching up with the developed nations. Their S&T policies are a role model for the developing world.

Korea is a small, resource-poor, country, having land area 220,000 sq km and 75% of its land is non-arable mountains, it produces no oil and virtually no valuable resources and supports 70 million populations. Korea’s international S&T cooperation evolved with industrial growth. In the beginning, Korea focused on building S&T capacity through international cooperation, and used it for technology-transfer. As the Korean economy grew the focus of international S&T cooperation policy moved to bilateral cooperation for scientific exchange, through joint research with advanced countries, such as USA, Japan and European countries. It is notable that it took Korea 3 decades, to transform itself from a poor foreign-aid recipient into a global actor in S&T. For transformation, it utilized S&T cooperation as a means of capacity building. Throughout the development process, S&T policy had been directed to technology-transfer as a means of technology-acquisition as opposed to indigenous technology-development. Thus, the international cooperation aspect of S&T policy was at the core of Korea’s development strategy. Starting in 1962, Korea launched first five-year economic development plan. This and subsequent plans created a huge technology demand. At the early stage, Korea had to depend upon imported technology and pursued two objectives of S&T international cooperation: promoting inward transfer of foreign technologies and developing domestic absorptive capacity to digest, assimilate and improve on transferred technologies.
Direct Foreign Investment (OFI) is the key factor behind economic success in countries like Singapore, Taiwan and Malaysia. DFI played a less important role in Korea as a source of capital and technology. This is because government policies restricted DFI in various ways. For instance, ownership restriction, repatriation restriction, technology-transfer requirement and export requirement. This was needed to avoid dependence on foreign technology and economic; as a result, DFI had a minimal impact on Korean economy (3.9%).

Korea tried to utilize International Cooperation as a means to build technological absorptive capacity. Between 1960 & 70s it made great efforts to link foreign aid to S&T capacity building. A most important achievement was to create KAIST, which was the first R&D institute in the country in 1966. KAIST helped industries improved upon new technologies and brought back many Koreans from abroad who had led S&T development, specially electronics, metals, machinery, bio-technology, oceanography and shipbuilding. This also produced the core of technology-absorptive capacity in 1970s and 1980s.

In order to sustain the development process, it was essential to build indigenous R&D capacity, and launched R&D Programme in 1982. In 1985, Ministry of Science and Technology, Korea launched a joint R&D programmes solely devoted to international collaboration by providing funds for small-medium research projects, aiming to help researchers establish and maintain international networks.

Over the period 1985-1997, the Korean government spent 52 billion Korean Won (US $ 50 Million) on this programme, of which 17% was for collaboration with U.S.A, 24% with Japan, 17% with Russia, 13% with Germany. Only 2% was used with developing countries. So, 70% of the programme was used with major developed countries during 1995—1997, major share was on collaborative research in new materials (20.8%), machinery, electronics (16.3%), information and communication (12.9%) and bio-technology (13.8%). This programme has proved to be quite effective. The total citation index (SCI) publication by Koreans over the period 1995-97, 27.6% was internationally co-authored, which is slightly higher than OECD average.

Korea is now a major R&D investor among OECD countries and ranks 8th in the world in the number of US patents granted (2001 USPTO). Korea has thus been able to grow economically to be a global player and joined OECD as full member in the later part of 1998.
Korea now has to go on further to participate actively in multinational programmes: this includes Human Genome Project (HGP), Human Frontier Science Programme (HFSP), the Intelligent Manufacturing System (IMS) and Inter-governmental Panel on Climate Change (IPCC).

4. SOME LESSONS:

Korea’s S&T Policy was effective in terms of capacity-building, technology-transfer, developing indigenous R&D infra-structure, sustaining and supporting their industry, using international cooperation with multi-nationals, as well as maintaining their independence from dominance of trans-national and multi-nationals, and protecting local R&D and industrial linkage. This was possible because of technological absorptive capacity based on a rich pool of well educated working force and good institutional framework for S&T development.

The Korean experience suggests that international S&T cooperation is a very effective tool for developing countries to build S&T capacity, backed by domestic absorptive capacity based on a well-educated work-force. Developing countries can also benefit from multinational S&T Programmes. For effective participation, the scientific community and government should work together, as such international engagement needs financial and political commitments as well. Some visible or invisible barriers and restrictions exist for broader participation in the world. However Multi-national programmes should be open to all developing countries or, at least, developing countries should be granted. This will contribute to the balanced growth in the world and ultimately reduce poverty, globally.

5. INTEGRATION WITH INTERNATIONAL TRADE ORGANIZATION: TRIP, TRIM & WTO

World Trade Organization and Relevant Agreements: The World Trade Organization (WTO) was created on January 1, 1995, to replace General Agreement on Tariff and Trade (GATT), adopting the GATT principles and agreements. The member countries have equal rights of votes and it presently consists of 149 countries. The main objectives of WTO are free and fair trade, to serve as a negotiating forum and to settle trade disputes. However it is observed that the WTO has in fact paved the way for widening the economic gap between
the rich and poor countries, resulting in making rich countries richer and the poor
countries poorer. Some of the agreements, where all parties are signatory but
adversely affecting the developing countries, are mentioned below:

• Trade-Related aspects of Intellectual Property Rights (TRIPS)
• Trade-Related Investment Measures (TRIMs)
• Agreement on Agriculture
• Agreement on Sanitary and Phyto-Sanitary
• Multi-Fibre Agreement

The bone of contention remains the agricultural subsidies, which the rich
countries pay to their farmers, amounting to one billion dollars a day. The United
States spends $3 billion in annual subsidies to 26000 cotton farmers. The EU
spends 40 percent on its budget on supporting its farmers. The developing
countries lose over $40 billion in agriculture export per year because of US and
EU subsidies and protectionism. This not only distorts the agricultural trade to
the detriment of the developing countries and depresses the prices of farm
commodities, but is gradually destroying agriculture in several countries where
it is the main pillar of economy and a source of livelihood to millions of people
living in thousands of villages. The agreement on services industries is the prime
example of rich countries’ domination over developing countries. Further
implementation of these agreements require emphasis on quality and standards,
to compete internationally. Although standards are necessary for purpose of
transparency in international trade, these can be arbitrary in nature and, at times,
unjustifiable and it is found that these can hamper trade.

Consequent to the previous WTO conferences in Seattle (1999), Doha (2001) and
Cancun (2003), the WTO Sixth Ministerial Conference was held in Hong Kong
from 13 to 14 December 2005, with much hopes, as any outcome of WTO
meeting is based on consensus and full agreement among the members. The
WTO members in Hong Kong have secured an end-date (2013) for all export-
subsidies in agriculture, they have an agreement on elimination of subsidies on
cotton by 2006 and they will allow 97 per cent apparel imports duty-free and
quota-free by 2008. The 50 poorest countries have been promised quota and
duty-free global market-access for 97 per cent of their goods. WTO has also
worked out a significant framework for full modalities on non-agricultural
market access (Nama). The rich countries wanted to cut on tariffs on Nama,
because services are supposed to be on higher side. The developing countries view was that the planned formula for tariff reduction might require them to make considerable large cuts in favour of rich countries. The Hong Kong Declaration leaves many points ambiguous and differences over modalities still block any real progress.

The developing countries should use the WTO platform to take practical steps forward, addressing international free-trade system. The freeing trade would stimulate economic growth, create better jobs and encourage innovation and improve living standards. These countries need to develop proper infrastructure and technical manpower to produce quality-products, in order to compete globally for marketing their products. Science and Technology inputs would form vital component in this exercise and regional/sub-regional cooperation needs to be sought. The developing countries may form groups or sub-groups to deal with various articles of the agreements already effective under WTO, so as to have firm bargaining position at the negotiation table. It is a fact that, all over the world, trade between neighbouring countries is higher. The trade within NAFTA is 60 per cent of their total trade; similarly 55 percent of the total trade of European Union is within the EU region. Therefore, it is in the interest of developing countries not only to seek various avenues for S&T cooperation but also to enhance commerce and trade among the neighbouring countries to make the development process flourish in peaceful and congenial environment.

6. ROLE OF INTER-GOVERNMENTAL ORGANIZATIONS AND INTERNATIONAL ACADEMIES IN POLICY-MAKING AND IMPLEMENTATION

Present era is the age of information and knowledge-based society, and the development of S&T has a direct impact on the approach and thinking of the people, planners and decision-makers in the developed or developing countries. The United Nations, other international and Regional organizations are playing significant roles in the development of S&T policies, infra-structure and are training scientists in their areas of specialization. The interactions of scientists and engineers have been enhanced among scientific community of South and North through regional/international meetings, conferences, seminars, workshops, short-term training, exchange of information and sharing of knowledge through internet. UNESCO, UNDP, South-South Cooperation, UNIDO and other similar UN
organizations have programmes for indigenous capacity-building, technology-transfer for sustainable development. Similarly, Regional organizations are also active in promoting regional cooperation in Africa, Asia and Latin America. SARC and ICIMOD are playing an active role in the development of South East Asian countries. International Academies like TWAS, IAP, AAS, IAS are also facilitating South-South and North-South collaboration enhancing and creating awareness for the centrality of science in socio-economic development. The following main international organizations and academies are promoting international cooperation/collaboration among developing and developed countries:

(a) COMSATS: 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 centres 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:

• **Sensitize to the Centrality of Science and Application of Technology:** This necessitates sensitizing 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;

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

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

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

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

• **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.

• **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 cooperation and promotion of S&T applications and their integration with national development.
(b) OIC Standing Committee on Scientific and Technological Cooperation (COMSTECH): The Third Islamic Summit Conference, held in Saudi Arabia, in January 1981, decided to establish a standing Committee on Scientific and Technological Cooperation (COMSTECH), to follow-up the implementation of the resolutions of the Islamic Conference, study all possible means of strengthening S&T cooperation amongst Muslim States, and to draw up programmes and submit proposals to increase the capacity of Islamic states in the S&T fields. The main objectives of the COMSTECH are assessment of the human and material resources, building up of indigenous S&T capacity, promotion of S&T cooperation and creating effective S&T institutional infrastructure for planning, research and development within OIC member countries.

Beside establishing the Islamic Academy of Sciences, it has established eight Inter-Islamic Networks in specialized fields of Biotechnology (Cairo), Oceanography (Izmir), Renewable Energy (Nigeria), Space S&T (Karachi), Tropical Medicine (Kuala Lumpur), Water Resources (Amman), Biosaline Agriculture (Dubai) and Information Technology (Islamabad). Two other networks on Veterinary Science and Environment are being established in Sudan. COMSTECH has an agreement with the International Foundation for Science, Stockholm, Sweden in supporting research for promising young OIC scientists, and funded 100 projects with IFS. The COMSTECH, in collaboration with IDRC, organized Inter-Ministerial Meeting on Biotechnology to utilize and monitor the benefits of “new biotechnology”, particularly in areas of agriculture, health and industry and ethical issues involved. It actively participated in the preparatory work for “Vision 1441”; the COMSTECH has a publication of over 11,000 pages containing Directory of Active OIC Scientists and their publications. COMSTECH, as a continuing activity, supports financially conferences, workshops and seminars in member states (20 during the biennium 2004-2005). New initiatives of COMSTECH include establishment of Institute of Advanced Training, joint research projects with WHO, linking education and research networks, arranging training courses and workshops. The 12th Meeting of COMSTECH, recently held in Islamabad from 21-23 February 2006, considered and approved the programme and budget for 2006-2007.

The effective implementation of the programme depends on the voluntary contributions from the OIC Member States, which are not forthcoming easily and regularly, as promised.
(c) **SAARC:** Soon after its establishment, the South Asian Association for Regional Cooperation (SAARC) comprising Bangladesh, Bhutan, India, The Maldives, Nepal, Pakistan and Sri Lanka, realized the importance of science and technology as a vehicle for economic growth and socio-cultural development of the region. Since 1983, the SAARC Technical Committee on S&T Cooperation has organized regular meetings and identified the potentials and scope for cooperation in research, training and scheduling of seminars and workshops in areas of importance to the regional countries. A Directory of Scientific and Technical Activities has been published, indicating the institutions identified in each country in the priority areas; the modalities for cooperation are indicated, including science policy, energy, food technology, remote sensing, microelectronics, genetic engineering and information exchange, etc.

(d) **Economic Cooperation Organization (ECO):** The earlier Regional Cooperation for Development (RCD) consisting of Iran, Pakistan and Turkey, was reactivated in 1984 and re-named as Economic Cooperation Organization (ECO), for harnessing their energies and pooling their resources to meet the challenges of modern times. The people of ECO countries are bound by profound ties of religion, deep cultural affinities, historical tradition and an identical outlook on life. Now ECO also includes Afghanistan and the six Muslim Central Asian Countries. Alongwith the Committee for Education, Scientific and Cultural Cooperation, sister institutional linkages are now being established for research, training and exchange of S&T information in the areas of agriculture, energy, nuclear sciences, oceanography and technology transfer, etc. As per Summit (1995), ECO Science Foundation, with headquarters in Islamabad, will be established soon for promotion and acceleration of science and technology development in the region.

(e) **ISESCO:** The Islamic Educational, Scientific and Cultural Organization (ISESCO) was established in 1992 at Rabat, on the pattern and functioning of the UNESCO, with the task of coordinating actions of OIC specialized agencies in educational, scientific and cultural fields and to initiate constructive cooperation with similar regional and international organizations and institutions, as well as taking other necessary steps to discharge its duties.
The ISESCO’s programme includes Islamic education, literacy campaigns, exchange of teachers, awarding scholarships, training, strengthening of science departments, publication of reference books, exchange of information etc. ISESCO publishes a journal “Islam Today” regularly. At the 12th meeting of COMSTECH, the Directorate of Science ISESCO presented the report of its activities. At the end of each activity, the analysis and evaluation results were outlined. The programmes dealt with capacity-building in water-resources, renewable energy, natural resources, biotechnology, establishing science-laboratories, publication of science text-books, supporting science-education and promoting research in social and human sciences. It is suggested that, instead of concentrating activities mainly in Rabat, the ISESCO should extend its programmes/activities in some of the least developed countries of the OIC.

(f) Islamic University of Technology (IUT): Islamic University of Technology (IUT) started its maiden journey as Islamic Centre for Technology and Vocational Training and Research (ICTVTR) in 1986, Islamic Institute of Technology in 1984 and culminated in the present position as IUT on 27 June 2001. It is located in Dhaka, Bangladesh; students and trainees from different OIC member states are pursuing various programmes on Science, Technology and Technical Education. It offers four-year courses in engineering (mechanical, electrical and electronics), computer science and information-technology; also post-graduate programmes leading to M.Sc. in technical education and engineering; and diploma courses in the mentioned subjects. Thirty OIC member-countries have been sending students to the IUT. The total number of graduates was 2,018 for the period 1987 to 2004, including 1,108 from Bangladesh. The IUT is rather hindered in making academic progress (due to shortage of buildings, well equipped workshops and highly qualified manpower) for want of finances and contributions from the OIC member states.

(g) Islamic World Academy of Sciences (IAS): The Islamic World Academy of Sciences (IAS) came into being in 1984, as a non-political, non-governmental organization that represents Muslim scientists of the various parts of the world. IAS’s main purpose is to increase interaction among scientists from member states of the OIC, and facilitate exchange of views on the major contemporary issues affecting the development of the Islamic World. The IAS is governed by a General Assembly, in which all founding and elected fellows are members, the present strength being 99. Its headquarters are located in Amman, Jordan. It
receives an annual grant from the Government of Jordan for administration and functioning, and the programme is financed largely by the COMSTECH and IDB. The IAS’s programme includes, formulation of Science Policy, organization of seminars and conferences, manpower-development, S&T publications and dissemination of information. So far, IAS has organized 14 international science conferences focusing on Food Security, S&T Policy, Manpower Development, Energy, Biotechnology, Technology Transfer, IT, S&T Education, and other subjects.

** TWAS: ** TWAS, the academy of sciences for the developing third world, represents the best of science in the developing world. Its principal aim is to promote scientific capacity and excellence for sustainable development in the South. TWAS is an autonomous international organization, founded in Trieste, Italy in 1983, by a distinguished group of scientists from the South under the leadership of the late Nobel laureate, Prof. Dr. Abdus Salam of Pakistan. Originally named “Third World Academy of Sciences”, it was officially launched by the then-Secretary General of the United Nations, Javier Perez de Cuellar, in 1985. Since its inception, TWAS’s operational expenses have largely been covered by generous contributions of the Italian government.

The Academy’s Fellows and Associate Fellows, more than 700, are elected from among the world’s most distinguished scientists. Fellows are citizens of the South; Associate Fellows are citizens of the North who either were born in the South or have made significant contributions to the advancement of science in the South. About 80 percent of TWAS’s membership are Fellows representing more than 70 countries in the South.

Since 1986 TWAS has supported scientific research in 100 countries in the South, through a variety of programmes. More than 2,000 eminent scientists worldwide, including TWAS members, peer-review proposals free-of-charge for research grants, fellowships and awards that are submitted to the Academy by scientists and institutions in developing countries. In 1988, TWAS facilitated the establishment of the Third-World Network of Scientific Organizations (TWNSO), a non-governmental alliance of 149 scientific organizations in the South. TWNSO’s goal is to help build political and scientific leadership in the South for science-based economic development and promote sustainable development through South-South and South-North partnerships in science and
technology. TWAS provides the secretariat for TWNSO and co-sponsors a number of its activities. TWAS also played a key role in the establishment of the Third-World Organization for Women in Science (TWOWS). TWOWS, launched in 1993, now has more than 2000 members, representing over 80 countries in the South. Its main objectives are to promote women’s leadership in science and technology in the South and to strengthen their participation in science-based development and decision-making processes. The TWOWS secretariat is hosted and assisted by TWAS.

Since May 2000, TWAS has served as the secretariat for the InterAcademy Panel on International Issues (IAP), a global network of 85 science academies worldwide established in 1993. IAP’s primary goal is to help member-academies work together to inform citizens and advise decision-makers on the scientific aspects of critical global issues.

(i) Islamic Development Bank (IDB), Jeddah: Realising that scientific and technological base is the main vehicle in creating and sustaining socio-economic growth, the Islamic Development Bank (IDB) has accelerated its activities in areas of scholarship programmes for graduate and post-graduate studies, promotion of information-systems network, research projects and development of regional centres. The IDB offered over 1000 scholarships in the last 20 years, including 160 for M.Sc. It approved financial support in the form of loans amounting $ 393 Million for 44 S&T projects in 16 countries while 21 countries received grants amounting to $ 2.580 Million for organizing seminars, conferences, workshops and training courses. The IDB has also initiated six S&T Network, Young Researchers Support Programme, the Centres of Excellence Scheme, the National Expatriates’ Programmes and IDB Prizes for Science and Technology. Some of these programmes are conducted in collaboration with COMSTECH and ISESCO. The IDB also actively participated in preparation of “Vision 1441 for Science and Technology” as a Member of the Task-Force established for implementation of the 10th OIC Summit Conference Resolution. The IDB needs to increase its S&T activities, as its programmes and projects are yet concentrated in less than half of the OIC member states.

(j) IDRC: A public corporation, IDRC was created by the parliament of Canada in 1970. IDRC’s objectives, as stated in the International Development Research Centre Act, are:
“…. To initiate, encourage, support, and conduct research into the problems of the developing regions of the world and into the means for applying and adapting scientific, technical, and other knowledge to the economic and social advancement of those regions…” In doing so, the Centre helps developing countries to use science and knowledge to find innovative, practical, long-term solutions to the social, economic, technological, and environmental problems they face.

Mission and Objectives – Empowerment through Knowledge: The Centre strives to optimize the creation, adaptation, and ownership of the knowledge that the people of developing countries judge to be of the greatest relevance to their own prosperity, security and equity.

• As set out in IDRC’s Corporate Strategy and Program Framework (CSPF) 2000-2005:
  • IDRC will strengthen and help to mobilize the indigenous research capacity of developing countries, especially directed to achieving greater social and economic equity, better management of the environment and natural resources, and more equitable access to information.
  • IDRC will foster and support the production, dissemination, and application of research results leading to policies and technologies that enhance the lives of people in developing countries.
  • IDRC will explore new opportunities and build selectively on past investments within its program framework.

IDRC identifies three broad thematic areas in which IDRC supports research. These areas represent an intersection of the priorities of the developing countries and IDRC’s potential to make a contribution to sustainable and equitable development:

• Environment and Natural Resource Management (ENRM):
• Information and Communication Technologies for Development (ICTFD)
• Social and Economic Equity (SEE)

Reaching out to Researchers: Support to Research Partners is an essential element of IDRC’s approach to programming and capacity building. One way in which IDRC provides that support is through its Research Information
Management Services Division (RIMS); RIMS offers access to the latest technical literature and disseminates the results of IDRC supported research.

In recent years, a service to provide online access to leading academic journals for individuals and institutions receiving IDRC funding was launched. Document delivery services are also offered when full-text versions are not available.

(k) United Nations Development Programme (UNDP): UNDP, the major development agency, in collaboration with FAO, UNESCO, WHO, UNIDO carries out country development programmes in the third world countries. The major component of each project is manpower development. One of its programme is called the Transfer of Knowledge through Expatriate Nationals (TOKTEN), operating in about 35 countries since 1977. The objective is to utilize expatriate nationals who had migrated to other countries and achieved professional success, and to mobilize them to undertake short term consultancies in their countries of origin. TOKTEN assignments are implemented through a process of need and supply. Domestic institutions determine which skills are needed and TOKTEN Programme identifies the most relevant consultant to fit the need. The TOKTEN approach is regarded as an added dimension of technical cooperation, which contributes to reducing the adverse effects of the “brain drain” with several advantages such as the shared language and tradition, knowledge of constraints in their home countries, low cost and expeditious implementation. The TOKTEN programme was first introduced in Turkey in 1977. In the 1990s, each year, 400 TOKTEN experts were assigned to projects of three weeks to three months. For example, in Pakistan over 900 consultancies have been carried out under the TOKTEN programme since 1980. Countries, whose TOKTEN Programme has been evaluated and claimed successful, include Turkey, China, India, Philippines, Palestine and Pakistan. The third world countries should avail such facilities available through the UNDP. Another organization, International Organization for Migration (IOM) provides financial assistance for medium and long-term assignments so as to accelerate the process of economic development through application of knowledge, science and technology. The major problem is communicating the requirements to the leaders of UN System and those outside, who may be in a position to assist in expansion of the development programmes.
(I) Consultative Group on International Agricultural Research (CGIAR):
The CGIAR established in the early 1970s works to promote food security, poverty eradication, and the sound management of natural resources throughout the developing world. CGIAR pursues these objectives through the multi-faceted activities of 16 international research centres located around the world. CGIAR members include 58 industrial and developing countries, private foundations, regional and international organizations which provide vital financial assistance, technical support, and strategic direction. The CGIAR system has the combination of resources and integrated approach needed to face the global crisis in food and agriculture. Some of the research institutes working under the umbrella of CGIAR are International Rice Research Institute (Philippines), International Centre for Agricultural Research in the Dry Areas (Syria), International Centre for Research in Maize (Mexico), International Institute of Tropical Agriculture (Nigeria), and International Water Management Institute (Sri Lanka).

The accomplishments of CGIAR include 300 varieties of wheat and rice, 200 varieties of maize, improved varieties of legumes, roots and tubers, pasture crops and other cereals. The Green Revolution has doubled productivity of such staples as wheat and rice. Some 50,000 researchers and scientists have worked and been trained at CGIAR Centres. CGIAR scientists are working in more than 100 countries. More than 600,000 accessions of germplasm are held in CGIAR genebanks. While the CGIAR accounts for less than 2 percent of the total global public sector investment in agricultural research, the work done by CGIAR centres and their partners has catalyzed agricultural research around the world. The CGIAR research agenda focuses on principal challenges in regard to: (i) increasing productivity; (ii) protecting the environment; (iii) preserving biodiversity (iv) poverty eradication and (v) strengthening national research. Each year the global population climbs by an estimated 90 million people. This means, at the very least, the world’s farmers have to increase food production by more than 50 percent to feed some two billion more people by 2020, mainly concentrating in the poorest countries of the world. Hence it is vital that the third world countries increase their R&D effort, in cooperation and collaboration with CGIAR, to increase agricultural productivity to feed the people and assist in food security.
7. CONCLUDING REMARKS

The developing countries should develop cooperative research programmes in area-specific subjects, actively participate in regional/international meetings and conferences, and avail training facilities wherever available. Intellectual mobility and interaction would add new ideas and new dimensions to the development of S&T infrastructure. Just take one example of food deficiency and food security. Over 75 percent of the developing countries meet their food requirements through import of food grains, edible oil, milk, meat and other livestock products etc. As a result, annually billions of dollars are drained out this way. Whereas CGIAR and its 16 international research institutes and scientists working in India, China, Egypt and Pakistan can cooperate with needy countries in solving various problems in agriculture. In improving agriculture hinges the prosperity and health of the rural populace.

To seek effective S&T cooperation with the friendly countries and international agencies/organizations, the first step required is to prepare a portfolio of priority areas including HRD component, financial requirement and resources, identification of possible foreign institutes, expertise and facilities that are available and a time-table to achieve specific targets. Bilateral scientific and technological agreements with friendly countries play significant role in augmenting the S&T effort. Quick decisions to accelerate S&T Cooperation is the need of the day, as there are many in the run to grab the opportunity.
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1. SCIENCE AND TECHNOLOGY AS AN INTEGRAL COMPONENT IN THE DEVELOPMENT PROCESS

Planning of science and technology itself is a relatively new concept. The preparation of S&T Plan, as an integral part of socio-economic plan, can only stem from a purposeful science and technology policy, which lays down directions for scientific efforts and identifies areas of technological improvement, to sub-serve the national goals. Many third-world countries prepare five-year development plans, each of which is further broken into annual development plans. The annual plan often has been a flexible document, in line with the overall plan-objectives, making adjustments in the light of progress made earlier. Only in the last 25-30 years, attempts have been made to incorporate the S&T sector into the national development plans, indicating separate allocations for S&T activities.

It is observed in many developing countries that, after an elaborate exercise for the preparation of the S&T component for the five-year development plan, the allocations requested to implement the S&T programmes and projects are often drastically slashed down, in view of commitments for other economic programmes and indicative flow of foreign aid/loan. Even the actual utilization of these allocated funds may vary between 75 & 80 percent of the allocation. The S&T system, as an integral part of the economic development process, has yet to be properly established in actual practice. Accordingly, in the next sections, we should discuss some aspects of the evolution of this, during the last 30 years by presenting aspects of the evolution of this S&T Planning process in 3 or 4 typical Asian countries. This would be followed by a proposal for an objective 15-year Plan broken up into three successive 5-year periods.
2. PREPARATION OF LONG-TERM S&T PLANS FOR SCIENCE AND TECHNOLOGY POLICY

Each of the Third-World countries should, therefore, prepare a well thought out comprehensive plan for the development of S&T as an integral part of its socio-economic development. This plan should clearly specify the objectives, identify thrust-areas for the plan-period, assess the requirements in terms of various inputs, including financial investment, and contain a time-related programme of action. Such a plan cannot be imported as a package from abroad or devised by the foreign experts. It should be developed indigenously, with the full participation of local professionals, educationists, industrialists, economists and planners. Accordingly, to provide guidelines, we describe briefly here the case-studies of a couple of Asian countries:

a- The Case of Malaysia

An excellent example is the technology plan, (called “Vision 2020”) for Malaysia, which was adopted in 1970 and which took several years to prepare. It has the full backing of the government and its implementation is monitored regularly. It has already put Malaysia on the right track towards industrialization. Although Malaysia represents only 2% of the total population of the Muslim world, its exports currently exceed 20% of the total exports of the Muslim countries. This is based on a combination of well-planned industrialization with appropriate S&T manpower-development, and attention on human priority concerns.

Along with proper S&T plans, the mechanisms for their implementation and the identification of focal points have been spelled out. This entailed establishment of a separate Ministry of Science and Technology for co-ordination and implementation of the S&T plan, viz to prepare a sound well-integrated base for providing education and scientific knowledge; while that of secondary education would be:

“To provide essential scientific knowledge that can form a coherent foundation for higher S&T education, training, and its utilization, in the light of traditional values.”

Efforts to undertake such as exercise had been started in several countries, soon after the Second World Conference on Muslim Education held at Islamabad in 1980, notably in Indonesia, Pakistan and Malaysia. In Malaysia, the effort
towards creation of the Integrated Curriculum for Secondary School (KBSM) started in 1980, in line with some recommendations made by the Report of the Cabinet Committee Studying the Implementation of Education Policy (1979). This Report also became a basis for the reformation of curriculum at primary school level i.e. Curriculum Planning for Primary School (KBSM), which was implemented in all the states of Malaysia by 1983. In brief:

The contents of KBSM include knowledge, skills, attitudes, and relevant values for the development of the potentials of students in a comprehensive and integrated manner, so that they become harmonious and balanced people in the intellectual, spiritual, emotional and physical aspects. The development of potentials of the students in intellectual aspects included the following elements to receive useful knowledge, develop thinking ability, arithmetical skill, problem-solving skill, reasoning as well as communication and interaction.

In structuring the learning-activities under KBSM, some subjects are considered as the core that is obligatory for all students. These subjects are for the fulfillment of the need for overall and integrated individual development. There are also some subjects that are optional or elective; the elective subjects are called additional subjects.

1. **Core:**
   - *In lower secondary the list of the subjects is as follows:*
     - Additional: Chinese, Tamil
   - *In upper secondary schools, the core courses are:*
     - Malay Language, English Language, Mathematics, Islamic Education, History, Physical Education

2. **Elective** subjects are divided into two groups:

First Group (Humanities) and Second Group (Science and Technology). Subjects included in the First Group are: Language, Literature, Art, Social Studies and Religion, whereas subjects included in the Second Group are: Science, Technology, Economics and Agriculture. Students are required to select two subjects from each group and one other from any group, making
up at least four subjects, or the maximum of five subjects. In this way, the balance is kept between humanities and science & technology in the structure of the curriculum.

The elective subjects fulfill the interest as well as the need for careers and higher education in various fields.

(c) Great stress has been laid on proper handling of the curricula and on preparing Guides for Use of Textbooks (GUTB) viz.

“All textbooks should be accompanied by Guide for the use of Textbooks for teachers. The main goal for this Guide is to help teachers on how the textbooks could be used most efficiently to achieve the goals, the philosophy and objectives of the syllabi.”

The results so far obtained in Malaysia, Indonesia, and some other countries, provide great encouragement for making similar efforts in other countries of the third-world to produce a population that is educated in the coherent practice of Science and Religion/Culture.

b- India – Four S&T Policy Cultures

In the developing countries, such as India, more than 75% of total S&T funding, including gross expenditure on research and development, comes from the government. Therefore, the politics and the policies of the government play a crucial role in the decision-making process relevant to S&T for development. This being an important feature in the understanding of the perspective of S&T policy cultures, there are other actors, agencies and institutions that hope to shape the overall structure of S&T policy. Heterogeneous, groups of different actors, ranging among politicians, scientists and engineers, academicians, diplomats, industrialists, business representatives, opinion leaders from the civil society and so on, collectively or otherwise influence S&T policies or goal-direction in science, and yield different patterns, frameworks, cultures or even paradigms. Four distinct but overlapping S&T policy-cultures – political bureaucratic; industry market; academic and civic – may be conceptualized as relevant to the Indian context. As Elzinga and Jamison (1994, page 573) observe, these policy cultures:

“... might be thought of ... coexisting within each society, competing for resources and influence, and seeking to steer science and technology in
particular directions. These cultures, which stand out as representative of the dominant voices, ... represent different political and social interests and draw on different institutional bases and traditions for their positions. Each policy-culture has its own perceptions of policy, including doctrinal assumptions, ideological preferences, and ideals of science, and each has a different set of relationships with the holders of political and economic power.”

As shown in Table 6.1, these four policy-cultures are conceptualized, with differing development & growth of science and technology institutions during the last five decades.

### Table 6.1: Outlines of the 4 Policy-cultures in India

<table>
<thead>
<tr>
<th>Development Priorities</th>
<th>Political-bureaucratic</th>
<th>Industry-market</th>
<th>Academic</th>
<th>Civic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defined by political priorities, in collaboration with technocracy</td>
<td>Defined by industrial and market demands and stakeholders</td>
<td>Importance of basic research, universities and academic excellence</td>
<td>Priorities set by democratic institutions, actors and processes</td>
<td></td>
</tr>
<tr>
<td><strong>Policy instruments</strong></td>
<td>State policies, plans &amp; S&amp;T statements</td>
<td>Market, private Industry mechanisms regulations</td>
<td>Peer evaluation and regulation</td>
<td>Public debates and participatory regulation</td>
</tr>
<tr>
<td><strong>Ethos</strong></td>
<td>Top-down/hierarchical Public good/profit</td>
<td>Entrepreneurial/competition/profit</td>
<td>Scientific/cosmopolitan values</td>
<td>Democratic/bottom up/public good</td>
</tr>
<tr>
<td><strong>Core constituencies</strong></td>
<td>Planning Commission, S&amp;T ministries, defence and science councils</td>
<td>Private/public enterprises, CLL, FICCI, chambers of commerce, market forces</td>
<td>Universities/science academies and councils/science community</td>
<td>S&amp;T movements, NGOs, civil society and its representatives</td>
</tr>
</tbody>
</table>

*Source: modified version based on Elzinga and Jamison (1994)*
India’s Experience in S&T Planning:

India’s first Science & Technology Plan (1974-79) made explicit reference to absorption & assimilation of technology and the development of indigenous capacity. The local research-development base in science-institutions continued to be viewed as crucial for the generation of technological capacities, as well as for avoiding technological dependence on foreign sources, including TNCs (transnational corporations).

In an effort to protect the local R&D base, the policies of self-reliance and import-substitution were strengthened during the 1970s and 1980s. The continuing emphasis on technology-absorption and innovation during the 1980s led to the announcement of the Technology Policy Statement in 1983, which further underlined the protective measures. By the early 1980s, India entered the nuclear and space ‘clubs’ of the world, experienced relative success in the ‘Green Revolution’ in food-grain production and the ‘White Revolution’ in milk cooperatives and development of the industry; India became self-sufficient in food grains, milk and other agro-industrial sectors – an important national task for a population of India’s size. Catalysed by the Indian Patent Act of 1971, which protected patents for only seven years, the CSIR laboratories were able to successfully exploit drug-patents in commercializing some important essential drugs. The goal of space-science for metrology, telecommunications and exploration of earth’s resources (water, minerals and so on) began to yield results for the first time since independence.

After the era of centralized S&T policy regimes, the trend in the post-liberalization phase has been more on the sectoral S&T policy regimes, which are constituted at the various individual ministries. Here the private industrial and commercial representatives, through appropriate specially created consultative bodies, now assume a greater role. This is clearly evident in areas such as telecommunications, information-technology, heavy industry, railways, and energy.

The industry-market culture and its various regimes and actors now play a major role in the civilian R&D sectors, where S&T policies are constituted in a sectoral manner at the ministries and science-institutions level. In a significant departure from the earlier phases, these sectoral S&T policies pick up signals from the
overall economic policies of liberalization and globalization. In the current era of globalization, which demands recurrent upgrading of skills and technology, industrial competitiveness makes a series of requirements: in-house R&D firms, expanding information-base of firms, quality assurance and support, appropriate policy and institutional support, aid firms in technological learning and, most of all, support and assistance to small and medium-sized enterprises (SMEs). As some analysts note, the Indian S&T structure is being transformed and made more responsive to industrial needs. There is also growing governmental support, through the venture-capital industry, and technology-development mechanisms for firms through state-support, but much of this is confined to the modern industrial sector.

Some Problems for Indian S&T: The major problem has been with the ‘making’ and ‘implementation’ or ‘theory’ and ‘practice’ of S&T policy regimes, atleast, in the last 15 years or so. In India, S&T policies so far have largely concentrated on the ‘input’ side of the R&D spectrum and left the ‘diffusion end’ to natural play of different actors. In the conventional sectors, engineering, design, instrumentation and enhancing the base of in-house R&D in industry, both public and private, which among other factors concern the diffusion-end of the R&D spectrum, have remained underdeveloped. The three main actors of national innovation system, the academic sector, science agencies and industry, still operate with weak linkages between them and often with relative isolation from each other.

The most dynamic sector, with considerable linkages between different actors responsible for innovation, has been in the defence and strategic-related R&D systems, including space and atomic energy. Compared to countries such as Japan, South Korea and the OECD (Organization for Economic Cooperation and Development), India is yet to evolve an innovation-policy which will bring about a coupling between different actors in S&T, on one hand, and market, on the other.

In the ongoing process of globalization, the idea of science as market good has come into operation, challenging the prevailing mode of science as public good. This is indeed a serious problem in developing countries, such as India, where over 80% of R&D is funded from public sources. As the operating mechanisms of market-driven commercial interests are increasingly applied to regulate research in publicly funded science agencies, there are signs of cutting down
research expenditure or stagnating public R&D funding in welfare, education, health, risk-related and other small-scale sector research all over, which enjoy considerable legitimacy under the ideal of ‘science as a public good’.

This is not to say that all is well with Indian science. The S&T efforts developed so far have enabled India to attain self-reliance in production for local consumption in several important areas, such as fertilizers, steel, manufacturing industries, mining and railways. India’s five decades of effort in higher education have given it some comparative advantage of ‘human capital’ in areas such as information technology. The same cannot be said about export-promotion and economic competitiveness in ‘high’ technology and ‘advanced’ technology-based industries, with some exceptions such as software.

Compared to China, though, India has attracted less foreign direct investment, and is emerging as one of the favoured nations for opening up R&D centres by the world’s big MNCs in the last five years. Many of these R&D centres have developed collaborative links with national S&T institutions. The main reasons for this trend are ‘cheap’ intellectual labour, expanding urban middle-class markets, which are huge compared to other countries, and a reasonably developed R&D institutional set up. To what extent India will be able to benefit from this new inflow of foreign R&D tie-ups and centres, is a big question as the MNCs are mostly involved in adaptive technologies rather than creative and advanced technologies.

3. HUMAN RESOURCE CAPACITY BUILDING FOR SCIENCE & TECHNOLOGY POLICY:

UNESCO, while considering the operational plan for the implementation of the Vienna Programme of Action on Science and Technology Development (1980), in relation to the training of specialists in Scientific and Technological Policy, Planning and Management, surveyed the Teaching and Research Units for Science and Technology Policy in different regions in 1983. The number totaled 1,117 units, with 65% concentration in the United States, Canada and Western Europe (see Table 6.2).
TABLE – 6.2
Geographical Distribution of Teaching and Research Units for
Science and Technology Policy

<table>
<thead>
<tr>
<th>Regional Group</th>
<th>Number of Units</th>
<th>% of World Total</th>
<th>Number of Units per 1,000,000 population</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States and Canada</td>
<td>368</td>
<td>33%</td>
<td>1.53</td>
</tr>
<tr>
<td>Western Europe</td>
<td>352</td>
<td>31.5%</td>
<td>0.89</td>
</tr>
<tr>
<td>Asia and the Pacific</td>
<td>152</td>
<td>13.6%</td>
<td>0.06</td>
</tr>
<tr>
<td>Eastern Europe (including USSR, Byelorussian SSR and Ukrainian SSR: 72)</td>
<td>112</td>
<td>10%</td>
<td>0.29</td>
</tr>
<tr>
<td>Latin America and the Caribbean</td>
<td>96</td>
<td>8.6%</td>
<td>0.29</td>
</tr>
<tr>
<td>Arab States</td>
<td>19</td>
<td>1.7%</td>
<td>0.13</td>
</tr>
<tr>
<td>Intertropical Africa</td>
<td>18</td>
<td>1.6%</td>
<td>0.06</td>
</tr>
<tr>
<td>Total</td>
<td>1117</td>
<td>100%</td>
<td>-0.2</td>
</tr>
</tbody>
</table>

The training can be accelerated and made more efficient through systematic training-programmes, which could be offered at the international, regional (or sub-regional) and national levels.

Objectives:

The main objective, as envisaged in the Vienna Programme of Action, was “the training of specialists required for the effective application of scientific and technological development policies in the Member states, and, more specially, in the developing countries.” The UNESCO proposed the following objectives that the “Institute” in question might pursue, although the situation will vary considerably from one country to another:

- to improve the knowledge of interactions between science, technology and society in general;
• to promote the progress and application of science and technology, with a view to endogenous development;
• to increase the developing countries’ capacity for self-determination in the formulation of policies and plans in the field of science and technology;
• to make known new or improved methods and procedures for the planning of scientific and technological development;
• to promote increase of productivity and socio-economic effectiveness of the scientific and technological system in the developing countries;
• to develop national expertise in the management of scientific and technological activities;
• to strengthen each country’s ability to choose, acquire, produce and adapt technologies;

The above list could of course be drawn up in different forms, without altering the basic content, on which there is very wide agreement. For instance a few decades back, Indonesia was an agricultural country, its economy based on agriculture. It, decided later on, that the application of research is the main vehicle in the development process, to achieve a more equitable distribution of development-gains leading to welfare of the entire population, a sufficiently high economic growth, and dynamic national stability. The subsequent technological transformation has been outlined in four phases (see Section-5 below).

One of the most significant factors in Manpower Development is the choice of emerging and new technologies for rapid advancement of third-world countries. A few such technologies are described below in some detail.

4. IMPORTANT NEW AND EMERGING TECHNOLOGIES FOR THIRD-WORLD COUNTRIES

Biotechnology

Traditional and Modern Biotechnology: Biotechnology is a collection of processes that involve use of advanced scientific techniques to alter and ideally improve characteristics of animals, plants and other forms of life. In brief, biotechnology is the application of science and engineering to the direct or
indirect use of living organisms. Biotechnology has made possible the selective breeding of plant hybrids, as a result corn production in the United States quickly doubled and yields substantially increased in the rice and wheat growing countries. More recently, IRRI scientists developed “Golden Rice” through fortification of rice with vitamin A, which is now responsible for reducing blindness in Africa and Asia. Biotechnology allows faster and more accurate production of new and more useful microbes, plants and animals. Traditional breeding has had inconsistent results but biotechnology is precise. Biotechnology is a useful tool in combating food shortages, undernutrition and diseases. However, mechanisms have to be developed in the Islamic countries to safeguard and to protect from exploitation and eroding the existing biodiversity by the transnational corporations. The TNC are the greater gainer in the process of biotechnology development and the poor countries has become poorer by loosing their genetic resources. in the traditional method of plant breading, still followed in most of the Islamic countries, farmer used to plant seed generation after generation (at least 3 to 4 plantings), but the seed obtained through modern biotechnology, he can plant the seed only for one generation. (it is called terminated seed) and for next planting he has to buy seed from one of the four world companies. Thus dependence on his quality seed is eroded.

**Some uses of Biotechnology for improvement of agriculture, industry and health**

**Agriculture:** Biotechnology has emerged as a new tool for the genetic improvement of crop using genes from diverse biological organisms. This has resulted in commercial release of soybeans, corn, cotton and other, crop varieties since 1996. Globally biotechnology has registered an unprecedented 60 fold increase during 1996-2006 decade, and in 2006, the area under biotech crops stood at 102 million hectares. Presently the leading countries in biotechnology crop plantings are United States (68%) Argentina (22%) Canada (7%) and (China and Australia each one percent. The prime reason for adoption of biotech crop is that biotechnology offers more environmentally free solutions for increasing yields and shelf life, for improving tastes and avoiding plant diseases as compared to traditional agricultural practices. Biotechnology is useful in production of biofertilizer for commercial crop so as to avoid dependence on hazardous chemicals. Biotechnology is also utilized to identify useful genes for different quality traits to improve crop production. Increase in population, the continual loss of prime agriculture land to housing and industry, loss of quality soil shortage of
wood based materials and quality timbers, low crop germination potential; all points towards biotechnology and its potential for plant improvement worldwide. Application of biotechnology to agriculture aims at accelerating the production of food and other agriculture products for industries and for export.

**Industry:** Recent advances in mutagenesis and recombination DNA technology have permitted enzymes working parameters to apply for commercial production of enzymes for use in textile, feed, starch and detergent industries. Biosulfrization of furnace oil is an attractive process as it enhances quality and price of furnace oil by about 30%. Genetically engineered bacteria and fungi can provide hydrogen energy as an alternate to other sources of energy.

**Health:** Biotechnology has improved molecular diagnostic tests for infectious and genetic disorder diseases and bulk production of therapeutic agents. Also has improved and made possible production of monoclonal antibodies for the diagnosis and treatment of malaria, typhoid, tuberculosis and hepatitis B&C (these diseases causing millions of deaths in Islamic world.). Gene therapy and stem cell therapy are being used for treatment of diabetes, cancer and other diseases.

**Research Groups in Biotechnology:** There are several research groups in the Islamic countries working on various aspects of biotechnology, including the COMSTECH’s Inter Islamic Network on Genetic Engineering and Biotechnology. There are 3 or more research groups on Biotechnology working in the ten countries under Category 1 including Pakistan but their effort is isolated and uncoordinated. But they need necessary support facilities, adequately trained manpower and finances for productive research with time targeted objectives. The concentration of research should be in areas like insect and disease, resistance in major crops, drought resistance, fermentation and enzymes production, fast growing trees, bacterial desulphurization of coal and petroleum, utilization of tissue culture techniques in flowers, fruits and vegetable crops, preparation of kits for early detection of cancer and other deadly diseases and improving animals production and health. These tasks need regional cooperation and precautions so as not to disturb the ecosystem. Supporters of biotechnology research are as concerned about its benefits as opponents are of the risks.

**Management of Biotechnology:** Earth Summit 1992 document has a separate chapter dealing with environmentally sound management of Biotechnology dealing with increasing availability of food, feed and raw materials, improving
human health, enhancing protection of the environment, enhancing safety and international mechanisms for cooperation and establishing enabling mechanisms for the development of the environmentally sound application of biotechnology. Some of the recommendations are still valid and applicable to our situations. They are summarized below:

- Increase the yield of major crops, livestock, and aquaculture species by using combined resources of modern biotechnology, including more diverse use of genetic material resources.
- To expend the use of biotechnology in forestry both for increasing yields and more efficient utilization of forest products.
- To promote the use of biotechnology, with emphasis on bio-remediation of land and water, waste treatment, soil conservation reforestation and land rehabilitation.
- Using the new tools provided by biotechnology, develop, inter alia, improved diagnostics procedures, new drugs and improved treatments and delivery systems.
- Evaluate the various biotechnology techniques to improve the yield of livestock, poultry, fish and other aquatic species.
- Exchange and compile information about the safety procedures in biotechnology.
- To strengthen the endogenous capacities to support research in order to speed up the development and application of biotechnologies and conservation.
- Raising public awareness regarding the relative beneficial aspects and risks related to biotechnology, and its contribution to sustainable development.

**Nano-Technologies**

**What is Nano-technology:** Nanotechnology is the technology where small-size materials are handled, used and products made out of these. How “Small” is the size of materials that are handled and controlled is the “real question” to understand its implications. The sizes handled and controlled are in measures of a few nano-meters, a nanometer being “one billionth” part of a metre. In terms
of common understanding, a nanometer (nm) is about 10,000 times (one lakh) thinner than the “human-hair and, in terms of scientific understanding, it is the size of a few atoms or molecules: about 10 atoms make the size of 1nm. This obviously means that we, today, have such precise instruments that now we can handle molecules and atoms. When atoms and molecules can be seen, handled, and controlled in the laboratory, the smallness of the products and devices made out of these can be well imagined!

For a student of physics it is easy to understand when we say that bulk laws of Newton fail when we apply them for atoms and nuclei. The quantum theory is the one which then deals better with atoms and nuclei, rather than the classical (bulk) theories in Physics. In terms of bulk aspect the “human-hair” is indeed considered as bulk. Therefore when the sizes used for investigating the physical properties are of such smallness, which is thousands times smaller than the diameter of human hair, one can understand the type of high technology required, particularly when we try to catch a human-hair lying on a paper and we try to pick it up by using a tweezer or, for that matter, we try to pick up one particle of talcum powder with a tweezer. It is interesting to mention that today, in a laboratory or a factory, we have available a “laser-tweezer” (two beams of laser light) which can displace atoms and molecules within a solid. On the other hand, we have an instrument called Atomic Force Microscope (AFM), which can handle one atom or a molecule and put it at another place wherever we want. The Atomic Force Microscope is a power instrument, frequently used today to handle atoms and molecules for the experiments using materials at the nano–scale size. In biological materials proteins (the important items for our food & life) are being studied and handled using these precise instruments.

This small-scale handling of proteins in the range of nano-meter sizes, holds great promise for bringing a revolution in the areas of medicine and healthcare, so that the complete diagnostics and treatment of terrible diseases like cancer and AIDs is in sight. With laser technology we are already able to detect objects the size of a few millimeter or about the thickness of match-stick, but body-cell is several thousands times smaller; the detection of cancer at cell-size could enable complete cure at the cell-level. Similarly, new drugs are being invented which will attack only the cancer cell as soon as it is produced and destroy it, then and there. This is the shape of the revolution in the field of medicine – at hand through nanotechnology, may be in the next 5 – 10 years!
Important Features of Nanotechnology: Here are a few noteworthy aspects of Nanotechnology, which show the urgent need for Islamic countries to go into this, along with the advanced and developing countries. The time, however, is running out fast, and will not wait for us.

- It is the technology of manufacturing items of small size at the nano-scale i.e. the individual molecules and atoms. The engines and rivets of small size are being built. The engines of bio-chemical molecules have been built and recently in Japan (Osaka University) a robot of a “bull” of the size of 1 micron (as thick as a “human hair”) has been built through atom-by-atom construction (just like a “brick by brick” construction or Lego game) and this robot is intended to go into the blood-cells and deliver pharmaceuticals for treatment of diseases. The bricks here are molecules of a plastic resin.
- It is a highly precise technology, dealing with precision at atomic and molecular dimensions, and
- It is highly multidisciplinary; having the intimate involvement of Physics, Chemistry, Biology, Engineering, Art and even the Social Sciences. Never before has a technology got so much inter-subject involvement.
- It is highly commercial and economic oriented, so that the business community is coming to regard nanotechnology as one of the leading industries of the 21st century, competing with the telecom and fuel industries. By 2012, it is likely to be a trillion $ industry.
- The central thesis is that, within the realm of any researcher (of science or art) he would find his own way to use nanotechnology and improve the extent of his current knowledge or improve his existing product. “He does not need to go out of his main field, but search within it, going deeper and interacting with others who may matter for him”. For example, a surgeon may have to interact with a materials physicist or materials engineer in order to understand the mechanical and corrosion properties of an implant (may be artificial hip joint, or parts of artificial heart, etc.) and know the precise details of its mechanical properties.

The spread of Nano-Industries: A recent survey revealed that, out of 1500 companies doing Nanotechnology business in the world, over 700 companies are in USA alone. In academics about 300 Nano-laboratories are working in the
universities and other centres of research in USA and, even at one compus, various departments are having separate Nanotech labs concentrating on separate areas of specialization in order to cover its different areas. Even the universities have set up Nanotechnology degree courses. So much so, that the first Ph.D. in Nanotechnology has come out at State University of New York in Albany, proudly advertised by this university on the web. The National Institute of Health (NIH) of USA has set up a specific centre, called Nano Cancer Centre (NCC), with about 144m $ allocated to the centre, for treatment of cancer and AIDS on cell – level in the next 5 – 10 years.

In China, over 300 organizations are involved in Nanotechnology and producing Nano-Materials of various kinds, be it metallic elements, compounds, alloys carbon-nabes, wires or nano-Porous materials.

Japan, where the term “Nanotechnology” was evolved as such, is spending more than 800m $ as government grant for Nanotech R&D.

Private companies of course invest heavily in Nanotech. In European countries, apart from individual country’s own Nanotechnology programme, a collective European strategy for Nanotechnology has been prepared in detail recently in December, 2004.

With the interest on counter-terrorism and home-land security the US Government further involved ministries to invest in Nanotechnology apart from the open prospects of great commercial future of this technology.

**Summary: Nanotechnology:**

1. Nanotechnology: Small-scale study, use, and fabrication of extremely small-scale devices through control and manipulation of atoms and molecules.

2. A Nano-size (or a Nano-meter a unit of size at Nano-scale) is one billionth of a meter and is about 100,000 times smaller than the thickness of “Human Hair”.

• **Making of Materials:** Particles and coatings: extremely hard (artificial diamonds), antibacterial, antiviral smooth coatings for industrial tools and medical use. Enhanced paints and glass, body implants, nano-pore membranes, energy storage, pollution control, cosmetics and sunscreens, textile coatings etc.

• **Nano-biotechnology:** *Human-device market,* implants (biocompatible materials in prosthetics and reconstructive surgery, biosensors detection and analysis, drug delivery, etc.

*Energy and Environment:* Efficient energy storage, efficient batteries, efficient fuel-cell, energy distribution, solar-cells technology, insulating materials, photovoltaic cells, nanotubes, nano-filteration, nano-porous sorbants, pollution-control, efficient building-materials.

• **Medicine:**
  - Prolong human life.
  - Biotechnology, pharmaceuticals, biosensors.
  - Treatment of Cancer/Aids at cell-size level.
  - Nano-Crystals for tracing anti-bodies.
  - Long life and biocompatibal implants (surgery and dentistry).
  - Small-size machines, robots, to move in the blood cells and arteries etc.

• **Computer Tech:**
  - More powerful computer faster than all computers on earth put together.
  - Data storage: all libraries of the world can be stored in space of inches.

• **Nano-art:**
  - Microscopically small sculptures – Osaka University has made
  - smallest “bull” 10 micron long, the width of a human hair, atom by atom.

• **Electronics and Photonics:**

Infrared detectors, integrated optical circuits, Si-based photonics, optical integrators for increasing speed of computers LEDs, fibre optic applications, ultra-high – bandwidth devices for communication, thin-film fabrication.
Quantum Computing:

- Use of single photon in optical fibres, to encode quantum information.
- Information Technology, storage of information.

Other Uses:

- Exotic Building Materials; Antiterrorism; Water Purification.

Mechatronics

Definition: Mechatronics is “the synergistic combination of precision mechanical engineering, electronic control, and systems-thinking, in the design of products and manufacturing processes.”

The purpose of this interdisciplinary engineering field is the study of automata from an engineering perspective and serves the purposes of controlling advanced hybrid systems. The word itself is a portmanteau of ‘Mechanics’ and ‘Electronics’.

Description: A Japanese engineer from Yasukawa Electric Company coined the term “mechatronics” in 1969, to reflect the merging of mechanical and electrical engineering disciplines. Until the early 1980s, mechatronics meant a mechanism that is electrified. In the mid-1980s, mechatronics came to mean all engineering that is at the boundary between mechanics and electronics. Today, the term encompasses a large array of technologies, many of which have become well known in their own right. Each technology still has the basic element of the merging of mechanics and electronics, but now also may involve much more, particularly software and information-technology. Compared to the traditional methods, the mechatronics approach is a more holistic approach to product-design, where the trade-offs between functional components are carefully considered for their impact on overall performance. Mechatronic principles have been successfully deployed in numerous applications, such as, hard drives, robotic manipulators, temperature control, and automotive systems.

Applications of Mechatronics: The following fields are believed to lie under the general category of mechatronics:
• Modeling and design
• System integration
• Actuators and sensors
• Intelligent control
• Robotics
• Manufacturing
• Motion control
• Vibration and noise-control
• Micro-devices and optoelectronic systems
• Automotive systems, and
• Other applications (Mechatronics is also used in animal production)
• This became feasible with the advancement of micro-electronics such as bio-sensors etc.)

Mechatronics in Islamic Countries: Mechatronics and its applications can enhance industrial productivity in developing countries. Its multidisciplinary approach is well-matched to the design of complex micro-positioning devices. Some universities in Turkey, Iran, Malaysia and Pakistan and other countries have already introduced this subject. However, there is dire need to build-up capacity and implement the technology in the industry of the Islamic world, over the coming decades.

4. Development of Science & Technology Policy in China  Since 1980s, China has experienced a change of economic system reform, from reforming micro-operational mechanism to reforming allocation-system for resources, and finally to setting up socialist market economy system in China. Meanwhile, China also has experienced a change of the science & technology system reform (STSR), from extending decision-making power of government-owned research institutions to reforming R&D funding system, gradually to introducing the market mechanism (namely the competition mechanism) into science and technology system.

China has made great progress in S&T legislation since the 1980s, and issued laws and regulations, including “Since and Technology Progress Law”, “The
Technology Contract Law”, “The Law for Agricultural Technology Diffusion”, “The Law for Dissemination of Science and Technology”, “The Law for Promoting Commercialization of Science and Technology Achievements”, “The Patent Law”, and “The Statute for Computer Software”. Besides, China has published lots of policies and measures ranging from setting the priority of research fields, science and technology system reform, platform for scientific research, industrialization of science and technology achievements, to promoting the talent mobility and international cooperation, so as to increase the supply of science and technology resources, to generate effective demand for science and technology, and to improve the innovation-environment in favour of the development of science and technology and the integration of the S&T and the economy.

The policy for science and technology in China comprises:
   - micro-management of S&T;
   - R&D;
   - S&T achievements;
   - Technology market & trade;
   - Inspiring and infrastructure;
   - Hi-tech and its industry development;
   - International cooperation.

The roles of science and technology policies and laws have changed a lot during the past two decades, in two directions, namely (a) changing their roles, and (b) extending their roles.

a- Changing the Role of Policies and Laws for S&T: Tax policies have become the most important measures for government to promote science and technology innovation. Tax-policies account for about 25% of total S&T policy and laws issued in the past two decades. Government, especially central government, is changing its role from managing R&D project to making policies & strategies for S&T and providing service and demonstration experiences, as socialist marketing economy system in China becomes increasingly more effective than before. Therefore, the role of national S&T programs in promoting S&T innovation tends to become less important, at present, although some government sectors used to manage R&D projects. For example, the Ministry of Science and Technology (MoST) is organizing all government sectors, scholars
from research institutes and universities, as well as experts from enterprises, to make the long-term planning for S&T development of China during the period of 2006-2020.

China has gradually improved its system of intellectual property rights (IPR) by revising related laws and regulations, as well as policies, especially “Patent Strategy” and Standardization Strategy” initiated and implemented by the MoST. The share of incentive policy-measures for property-right encouragement increases gradually. Evaluation and license, as well as standardization, play increasingly important role in promoting science and technology innovation.

b- Extension of the S&T Policy: The acquisition and export of technology still play a very important role in economic development, while S&T policies gradually pay more attention to international S&T cooperation and competition. Industrialization and commercialization attract more attention than new-product development in the S&T policies, which implies that government pay more attention on industrial development instead of product-development, on engineering and marketing as well as market development, instead of technology development. The S&T policies pay increasingly more attention to hi-tech enterprises and foreign invested enterprises, as well as large-middle sized enterprises, so as to promote science and technology innovation.

c- Effectiveness of S&T Policy: Promoting the Reform of the S&T System
After 20 years of incremental reform on operational mechanism, with a view to strengthening the linkage between production and research, for example, to decrease governmental budget for applied R&D institutions gradually, so as to force them to survive in the market, and to encourage R&D institutions and universities to exploit the economic value of S&T research by setting up their own companies, the Chinese Government decides to withdraw from some competitive sectors and take some radical reform measures. Since 1999, China began to transform government-owned research institutes into enterprises, with a view to strengthening national innovation system, especially the capability of technological innovation at enterprises-level. At the national level, the first batch of 242 research-institutes affiliated to former State Committee for Economic and Trade and the second batch of research-institutes affiliated to other Ministries have been transformed into enterprises by the end of 2001.
However, the transformed research institutes still play very important roles in promoting progress of industrial technology. They took over lots of projects of the national science and technology program and provided technology-service for enterprises. For example, 242 transformed research institutes receive 676 million yuan RMB, took over the projects of national S&T programs, and earned profit of 1.1 billion yuan RMB with 9.1 billion yuan RMB of sales revenue in 2002.

In recent years, enterprises have gradually become a principal part in the technology innovation. The technological innovation capability of enterprises has been increasingly strengthened according to new results on evaluating 302 technology-development centers of large enterprises.

Universities have become a significant base for generation & diffusion of knowledge and technology innovation, as well as commercialization of S&T achievements. Universities account for about 17.5% of total full-time equivalent R&D personnel, while research institutions and large and medium-sized enterprises, respectively, account for 19.9% and 41.0% of total full-time equivalent R&D personnel in the year 2002. The universities, research institutions and large and medium-sized enterprises accounted for 22.4%, 30.1% and 35.8%, respectively, in 1998, which indicates that more and more R&D personnel concentrate in large and medium enterprises.

Universities accounted for 10.1% of total R&D expenditure, independent research institutes accounted for 27.3%, enterprises accounted for 61.2% in 2002, as against which the share of the universities and the independent research institutes was 10.4% and 42.5% respectively in 1998. This further shows that enterprises have become principal part of innovation.

The Chinese Academy of Sciences (CAS) has significantly strengthened its competitiveness by implementing the “Knowledge Innovation Program”. The number of SCI papers published by CAS surpassed Max-Plank Society (MPG) in 2000, and 4109 units more than MPG in 2003, while the number of SCI papers published by CAS in top twenty journals of each research field has increased faster than that of MPG and CNRS, from 20% of MPG and 17% of CNRS in 1998 to 53% of MPG and CNRS in 2003; this shows that the gap in quality of published papers now tends to be smaller. Besides, CAS accounts for more than 50% of papers published by Chinese in *the “Science” and the “Nature”*, and 54% of that in the top twenty journals of each research field.
**d- Integration of S&T with the Economy:** The technology capabilities in the sectors, such as energy sources, resources, raw materials, communication, and machine building, have been dramatically improved during past two decades. In recent 10 years, the productivity increased by 11942 yuan/per person, the energy consumption/10 thousand GDP decreased 2.69 ton standard coal. Mechanism for cooperation between industry, universities and research institutes has gradually been established. Enterprises engaged in 90% of all projects of the National S&T Program for Key-Technologies R&D, while 80% of large enterprises have established cooperation with universities and research institutes. The transformation of the 242 R&D institutions strengthens the linkage between R&D and production, and the technological innovation capability of enterprises, to some extent. The share of scientists and engineers in state-owned independent research institutions decreased from 31.5% of the total in China in 1991 to 21.5% in 1998. The share should be much lower than before, as soon as all state-owned independent research institutions have been transformed. The fact that the share of R&D personnel in state-owned independent research institutions has been gradually decreasing which implies that more and more R&D personnel join in industrial sectors. Enterprises are gradually becoming the principal innovator and investor in R&D.

The transformation has changed the research-model of state-owned independent research institutions from government-oriented to being market-oriented or following foreign research-organizations. Although state-owned or those following foreign research-institutions are encouraged to run business for about 20 years, but performance of researchers is still evaluated according to academic indicators, such as academic papers and experiment results, not the economic value of research results. The purpose of R&D institutions to run business is to make money, so as to survive, not just to meet the technological demands of enterprises. As soon as these state-owned independent research-institutes are transformed into enterprises, to maximize profit, the nature of enterprises will push transformed independent research-institutes to develop what the market needs and then to quickly commercialize them. Besides, the transformation itself also provides many opportunities for the combination of technology and capital, which enable transformed R&D institutions to enlarge their share of market.
5. BUILDING UP THE INDIGENOUS CAPABILITY OF S&T

d- China

S&T infrastructure has been improving gradually since the 1990s. During the past ten years, China has put large amount of money into big science projects, instruments for large experiment and S&T documents/data bank. The sharing mechanism for S&T infrastructure has been highly emphasized in S&T policy measures. Besides, the Chinese government is making long-term plans for S&T development (2006-2010), with a view to supporting national social & economic development. The first stage of the strategic research for the long-term planning ranges from macro-strategy research to key S&T assignments, and S&T input & policy environments.

The macro-strategy research concerns the general strategy for S&T development, the S&T system reform and national innovation system, while the key S&T assignments concern the manufacturing and agriculture sectors, the energy, resource and oceanic technology, the transportation and communication and the modern service sectors; these cover the issues related to the population and health, the public security, the eco-reconstruction, environment protection and recycling economy, the city development and urbanization, the strategic hi-tech & industrialization, the national defense and the basic science issues. The main purpose of studying the key S&T assignments is to determine the S&T priorities. The S&T input & policy environments concern the equipment and infrastructure for S&T research, the S&T talents, the S&T input and its management, the laws and policy for S&T development, the innovation culture and popularization of science, and the regional S&T development.

The expenditure on S&T in China has increased steadily since 1998. The expenditure for R&D researches rose to 128.76 billion yuan RMB in 2002, about 1.23% of GDP. There were 3.22 million S&T personnel in 2002 in China, including 2.17 million scientists and engineers, about 22.7% and 39.8% higher than that in 1995. The sales of new products accounted for 13.2% of total revenue from the sale of products in 1999, and 16.1% in 2002. The expenditure on purchase of domestic technology in large and medium-sized enterprises of China accounted for 1.63% of expenditure on technical renovation in 1999, and 2.88% in 2002, while expenditure on technology-absorption accounts for 2.14%
of expenditure on technical renovation in 1999, 1.72% in 2002 (see table 6.3). This demonstrates China’s interest in speeding S&T inputs towards economic development and prosperity.

China ranked at the fifth position, in terms of published SCI papers in the world in 2002, and became one of countries with advanced spaceflight after the successful launching of the manned spacecraft “Shenzhou 5” in 2003.

Table 6.3: Major Indicators for S&T in Large and Medium-sized Enterprises (100 million yuan)

<table>
<thead>
<tr>
<th>Item</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expenditure on Technical Renovation</td>
<td>845.6</td>
<td>1132.6</td>
<td>1264.8</td>
<td>1492.1</td>
</tr>
<tr>
<td>Expenditure on Import of Technology</td>
<td>207.5</td>
<td>245.4</td>
<td>285.9</td>
<td>372.5</td>
</tr>
<tr>
<td>Expenditure on Technology Absorption</td>
<td>18.1</td>
<td>18.2</td>
<td>19.6</td>
<td>25.7</td>
</tr>
<tr>
<td>Expenditure on Purchase of Domestic Technology</td>
<td>13.8</td>
<td>26.4</td>
<td>36.3</td>
<td>42.9</td>
</tr>
</tbody>
</table>

b- An Example The Four Phases of Technological Transformation in Indonesia:

The philosophy of technological transformation in Indonesia is based on a four-phase process that will lead to the creation of a technologically and industrially developed society. Three of these phases are particularly relevant to less developed countries, such as Indonesia, whilst the fourth phase is vital to all countries concerned with the preservation of technological prominence. The four phases are as follows:

**Phase 1:** The utilization of already existing technologies for value-added processes involving the assembly and manufacture of products already in the market.

Technologies are used to transform raw materials and partially processed goods into finished products with a higher added-value. This first phase does not guarantee technological advancement. The logical short-cut to technological advancement is to import technologies from abroad and manufacture under a license. Progressive manufacturing programs are required to help ensure the systematic transfer of licensed technologies. Through such programs, an understanding is gained of more advanced designs and processes.
Phase 2: Integration of existing technologies in the manufacture of new products.

The integration of existing technologies into new products adds an element of creativity, in that it involves the development of design-capabilities, with an emphasis on the skills of integration and optimization of components. Such designs can only enter the market-place when they are integrated into an existing or future product. This phase also demands a critical review of the existing technologies available for adaptation. A new product must be developed and, therefore, the role of research and development is pre-eminent.

Phase 3: Development of improved technology; existing technologies are revised and improved.

The third phase is a phase of innovation, that is the creation of improved technologies to develop components for integration into products that will become innovative in their respective markets. This phase has a crucial role in ensuring that the advances made in the first two phases are effectively utilized. Countries that reach this third phase will often find that there are gaps in theory, which necessitate investment in basic research and a progression to the fourth and final stage of industrial transformation.

Phase 4: The development of basic research capabilities that allow a country to innovate and develop technologies.

This fourth stage of transformation is the means by which a nation seeks to maintain and build on the advances it has made in the preceding three stages. While some developing countries are able to invest part of their resources in basic research, many find that other priorities intercede. This is because many resources (e.g. financial, human and material) are scarce and are often allocated to more urgent tasks. The result is that the great bulk of basic research takes place in developed countries, depriving the developing country of the opportunity to innovate and develop technologies.

c- Suggestions to Improve S&T System:

Prof. M.J. Moravesik had presented a paper as long ago as 1983 at the International Conference on Science in Islamic Polity, at Islamabad, in which he
made suggestions/recommendations aiming to improve the S&T system communication-channels in the Islamic countries. These are still relevant to most third-world countries and are summarized below.

**Recommendation 1:** The specific programmatic work to be done should be carried out *through a number of task forces*, each established for one particular objective. Task forces should not contain more than ten members, should exhibit some geographical distribution, should include both active scientists and science-policy makers, but in any case, should contain only people who have a commitment to a considerable amount of work to be done within the task force. Each task force should be given a specific mandate and a deadline by which its recommendations/proposals are to be formulated. After the recommendations are available, the task force may be given additional mandate to implement them.

**Recommendation 2:** A task force be established to find ways to *gradually eliminate* *rote learning from the science curricula* of Islamic countries. Among the methods to be used are open-book examination, the stressing of problem-solving in teaching methods, courses built around problems, rather than disciplinary lines, etc. Once recommendations are available, they may be tested on a small scale, perhaps in special schools, and then applied more broadly. Recommendations of this task-force are expected to affect institutions for training of teachers as well.

**Recommendation 3:** A task force be established to bring about the *elimination of premature specialization in the educational institutions*. This is mainly a curricular matter, but in order to make such curricular changes, much persuasion will be needed to convince those in charge of educational systems that broadening the students’ education is indeed in the interest of more productive science.

*In order to develop a successful S&T system, a number of pre-requisites are essential before the activity could be meaningfully started. These include universal basic education, availability of sufficient numbers of scientists and engineers, well thought-out national development plans, completed in conjunction with a properly drawn up Science and Technology Policy. This is, of course, in addition to the basic input of funds. These pre-conditions are still valid today.*
6 (a) Basics for Fifteen-Year Action Plan for Typical Third-World Countries

There is urgent need for the ulama and religious scholars to give up the centuries old fallacious idea of antagonism between science and religion. They should take a lesson from the history of Muslim scholars, such as Ibn-e-Sina, Ibn-ul-Haitham, Umar Khayyam and many others, whose works and researches were later the source for bringing about the renaissance in Europe after a prolonged period of darkness & domination by the Church, which suppressed science and enquiry.

It is interesting to note that Imam Ghazali in his famous books, Ihya-ul-uloom (Revival of Learning) and more particularly al-Munqidh min-al-dalal (Deliverance from Error) says: “Another difficulty is created by a bigoted follower of religion who thinks that in order to save religion, it is essential to deny all science”, (translation by Dr. M.R. Siddiqi), “As a matter of fact, there is nothing in religion which is against the sciences, nor is there anything in the sciences which is against the religion”. (Al-Munqid). It should be remembered that more than 300 years after the exposition of Ghazali, great scientists like Bruno and Galileo were persecuted and punished in Europe for preaching some new scientific theories and discoveries.

We find there is a great deal of continuing orthodoxy in the outlook of Sufi and Mashaikh who follow the path of “tariqat” as opposed to the rationality of the teachings of prophets of Allah and the Shariah. In order to balance himself between the often opposing forces of materialism and spiritualism, man stands in need of a full model that can be understood and followed in practice.

Such a model is provided by the Sunnah of Prophet Muhammad (S.A.W.) who obeyed and amplified the commandments of Allah by his precept and personal example. The basic guidance is provided in the Holy Qur’an, which is a book of social and moral guidance but at the same time draws a great deal of strength from references to Allah’s creations in various forms in the world and the universe around us. This implies a state of harmony between our spiritual aspirations and the study and use of nature, which requires reconciliation of the two sources of knowledge, the reason and revelation.

Fortunately, we today have a better and more balanced view of the supernatural, in the light of various modern theories and concepts of the Physical Sciences. There are some eminent scientists (including non-Muslims) who believe in the
complementarity between science and religion and their concordance and integration for the benefit of humanity. The basis is the fact that a whole lot of actions stem from what one believes and so a Muslim will take up S&T activity wholeheartedly only if it can be seen to give and fit in with his basic beliefs.

In the recent period, there are signs of change for bringing about an integration of the two sources of knowledge for developing a holistic worldview. Efforts have accordingly been made by some countries, such as Malaysia, to this end by preparing Integrated Syllabus at the elementary school level.

**Outline Plan**

This outline has been drafted in the light of the strategy of such integrated curricula and the needs for education at the various levels discussed above. Due emphasis has been placed on the scientific and technological components of education at the primary, secondary, vocational as well as tertiary levels.

The first and second rows in the Outline Plan deal with the progressive development and gradual implementation of integrated curricula at (i) Primary Schools and Technical Schools and (ii) Secondary, Vocational and Technical Schools. An effort has been made to divide the Plan, as far as possible, into successive five-year periods, with smaller sub-divisions of two years where needed. The integrated curricula can probably be fully made operational in the third five-year period.

In the third and fourth rows, the corresponding process has been outlined for the case of (i) Degree and Technical Colleges, and (ii) Universities and Institutes of Higher Learning. The success of this process will largely depend on two major factors: (i) the quality as well as quantity of the inputs from the first two educational levels, and (ii) the extent to which the college and university teachers can be made to accept and adopt the somewhat radical concepts and suggestions given above.

The last row gives a rough picture of the essential interactions required between Universities R&D and Industry, which would lead to technology development, cooperation between industry and R&D institutes, ultimately resulting in the establishment of operative R&D groups within selected industries. This interaction would hopefully set the stage for the development of sound industrial
policies, with special emphasis on technology development/transfer and Regional Cooperation in the long-term perspective.

### Table 6.4: Schematic Outline for Fifteen-Year Action Plan (2006-2020) in 3 phase

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>I</td>
<td>Framing/Development of integrated Curriculum Textbooks</td>
<td>Teacher Training at Primary Level</td>
<td>Integrated Curriculum Teaching at Primary Schools</td>
<td>Dialogue for Coordination between Madrasah &amp; Traditional &amp; Western type Education</td>
</tr>
<tr>
<td>II</td>
<td>Curriculum and Textbooks Development with emphasis on Practical in Secondary and vocational schools</td>
<td>Introduction of Group Activity in Secondary Schools and Vocational Schools</td>
<td>Training of Teachers for integrated curriculum at Secondary and Technical Schools Levels</td>
<td>Integrated Curriculum made operational at Secondary and Technical Schools level</td>
</tr>
<tr>
<td>III</td>
<td>Development of Curricula for Degree and Technical Colleges</td>
<td>Plan for Training of Teachers for Scientific Methodology at Degree and Technical College Levels, including a component of Social Sciences and Humanities</td>
<td>Cooperative Research Activity in Degree and Technical Colleges in emerging fields, e.g., Bio-Tech, Electronics, etc</td>
<td>Training of Teachers for integrated Curricula at Degree College Level</td>
</tr>
<tr>
<td>IV</td>
<td>Plan for Curriculum Updating and Practical Activity at University Level</td>
<td>Plan for Research at University Level</td>
<td>Establish Practical and Group Activity at University Level</td>
<td>Establish R&amp;D Groups in Universities and Institutes</td>
</tr>
<tr>
<td>V</td>
<td>Initiate Dialogue for University R&amp;D Institute, Industry Cooperation</td>
<td>Initiate Proposals for Technology Development and Industrialization</td>
<td>Plan for University - R&amp;D Institute - Industry Cooperation</td>
<td>Plan For Inter-Islamic S&amp;T Policy</td>
</tr>
</tbody>
</table>
6(b). Schematic Base of Action Plan for Typical Third World Countries

A basic plan to achieve the aims described above needs to be developed for various Third-World countries. It can be outlined as follows, with four major thrusts:

- Sustained efforts shall be made to develop the creativity of the students by coordinated re-awakening of the latent moral & social values, emphasizing the balanced and just way of life which had been the base for the early civilization’s progress in knowledge and science. The foundation for this should, in fact, have been laid at the primary level as in case of Indonesia and Malaysia, where the primary curriculum for classes I-III has been integrated into two books only; one integrating language, religion and science, and the other dealing with mathematics & its branches.

- At each appropriate level, books on Traditional Studies should be included, presenting the religious view in coherent juxtaposition with the scientific and technological worldview, and recognizing that moral reformation has to precede the scientific and technical uplift of the community.

- During the learning/teaching process, it should be incumbent upon the teacher to present himself as an exemplary person and to explore practical Religion-Science relationship;

- Teaching of Science should have three main aims:
  - To develop a rational and critical aptitude for observation of natural phenomena;
  - To inculcate mental skills to develop coherent theories of natural phenomena based on the observed data;
  - To enable persons to build on previous knowledge and work collaboratively for unraveling the laws of nature.

In order to achieve these aims, it is imperative to make the history and philosophy of science during the last two millennia, an essential part of the curriculum of the science subjects. Philosophy of science helps to develop a holistic view of the universe and the interactions between culture and science. History of a particular science-subject should underscore the element of never-ending continuity of the scientific activity and the contributions made by the scientists from various civilizations in the pre-modern period.
Indicated below is a Ten-year plan base for the secondary level, broken up into two successive five-year periods, indicating the above-mentioned basic features. Individual countries would hopefully develop the details independently, bearing in mind the outcome indicated earlier in Table 6.4 for the third five-year period.

Chart 6.5

- **First Five-year Plan (2006-2010)**
  - Integrated Curriculum Development, Teacher Training, Teaching at Primary School level
  - Emphasis on Practicals and Introduction of Group Activity at Secondary School Level and in Vocational Schools

- **Second Five-year Plan (2011-2015)**
  - Plan for coordination between Traditional Education and Western-type Education: (Policy + Dialogue)
  - Training of Teachers for Schools & College for Integrated Curriculum: (Teaching at Secondary Level)
The effective dialogue between the leaders of Traditional and Western-type education would have a crucial role in the successful implementation of the above plan. An attempt has been made in Indonesia, Pakistan; other countries may follow the mentioned outline in selected modern and traditional schools.

In the process of implementation of the National Science and Technology Policy and its Action Plan, it is necessary to start an exercise in formulation of sectoral science and research policies in areas of agriculture, industries, housing, communication, education, construction, energy, environment and other relevant sectors. The caution is to work within the ambit of objectives and strategies of the national S&T Policy. By way of example the Energy Policies for the Third World Countries is appended.
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14. Micro positioning meets Mechatronics
In the beginning of this book, historical perspectives regarding science and technology have been given. There is a greater realization, more now than in the past, that each country should develop its own National Science and Technology Policy for socio-economic development, and also to ensure the mechanisms for its periodical review, so as to synchronize with the socio-economic development plans. The applications of science and technology in the developing countries still suffer from various drawbacks, particularly lack of awareness of its role in enhancing industrial development, which is reflected in low involvement and expenditure by the private sector in research and development. The general system of S&T research activities in developing countries is characterized by weakness of coordination, and dispersal without common linkages, rather than being concentrated in key-areas with efforts towards developing synergies. This dispersion and disconnection often results in unjustified duplication and wastage of the meager resources allocated for research. It has been noted that countries whose policy frame-work is strong, are better able to achieve practical and significant results through their efforts in science and technology, because the international and local situations are changing rapidly.

Under the new trading environment of the world, there is a need to appraise past developmental strategies and prepare the country to face new challenges. The second chapter of the book highlighted the factors which hinder technological development, and provided a basis for new strategic directions for the technological base. Science and Technology Policy is today assuming a pivotal role in shaping not only the S&T programmes in Third-World countries, but is also strongly influencing programmes for economic and industrial development. It is very important to identify the main needs of a country and launch import-substitution and export-oriented programmes, directed towards transfer of
technology and technology-development, in order to achieve self-reliance in key fields. The priorities should include conversion of raw materials to value-added products, manufacture of materials with export potential and awareness of niche opportunities, such as those now available in biotechnology, information technology or nanotechnology for optimum benefit. The funding mechanisms at the disposal of the governments, through research-funding agencies, can ensure that a significant portion of the research effort is directed at such targeted programs, with the objective of developing indigenous technological capability.

The Third World Countries are facing new challenges, because of ever-growing population, increased poverty, unstable economies, migration of highly qualified S&T personnel to the West and depletion of natural resources. The major components identified to improve the situation are: (i) high level of literacy and quality education at all levels, (ii) gradual upgrading of the universities and research centers to international level of excellence, through development and retention of researchers and provision of appropriate research facilities, (iii) application of resources of research and development for industrial development, (iv) re-structuring governmental policies and mechanisms to encourage investment by entrepreneurs in indigenously developed products and processes, and (v) introduction of merit-based system, with accountability at all levels, so that the most creative people can be inducted and encouraged to attain positions of leadership.

Another crucial aspect of the critical situation of science and education in developing countries is the “brain-drain” from these countries. The causes of the “brain-drain” are many: lack of academic and research environment, lack of facilities, lack of professional fulfillment, low salaries, the natural attraction for the high standard of living in the developed countries, wars and civil wars, etc. Thus, not only do the developing countries contribute to the wellbeing and riches of the industrialized countries, through the massive outflows of capital, in terms of interest-payments on debt and the effects of the deteriorating terms-of-trade, but also they contribute their best and brightest brains for the further advancement of these already very rich countries. It would be interesting to determine, for example, how many scientists and technologists of developing world (origin) have contributed to the growth of the high-tech industries in the United States.

We all know that Science and Technology is a source of power, wealth & prosperity. Nations are in competition with each other to acquire technology for industrial
growth and defense. Science and technology, as available at the international market, can never be shared by all countries. Many pressing issues, like brain drain, lack of scientific infrastructure and expertise and other geographical and political causes are creating a huge gap between developing and developed states. It is, therefore, necessary to promote S&T indigenously, especially to build up local regions, and international capacities for socio-economic uplift – specifically for the 2 billion people living below the poverty-line. Gainful S&T transfer for developing countries has, consequently, become a critical area of foreign policy and there is selective sharing, based on geo-political and ideological orientation. International cooperation, both south-south and north-south, is imperative for strengthening S&T applications for socio-economical development in the developing world. Sharing of human resources, using capacity-building approaches and technology transfer, is today the basic foundation for S&T development in any developing country. Accordingly, key-recommendations are given below for this.

**RECOMMENDATIONS**

**General**

1. The newly industrialized countries should assist and cooperate with the least developed countries in the development of S&T manpower. One of the major goals of a S&T Policy is to develop the full range of S&T personnel needed for economic development and for absorption of state-of-the-art technologies, as well as development of new technologies, products and processes that are required for boosting the agricultural and industrial production, and modernizing and streamlining transport, communications, health and defense sectors.

2. The policy-formulating bodies should draw-up the organizational structure and operational mechanism and specify the responsibility of each group to handle different policy-instruments. S&T Policy that is truly public-supported, private sector-driven, and performance-based should be finalized and implemented solely by the practioners on the ground.

3. The governments of the developing countries should increase their science-budgets significantly. As recommended by the UNESCO in the 1980s, they must allocate at least 2% of their budgets for scientific research, to produce any significant economic impact.
Linkages & Cooperation:

4. Developing countries should make efforts to build the infrastructure, manpower, and industrial linkages, as well as create awareness in the private sector to use local technologies.

5. The linkages between academia, laboratory scientists and industrial entrepreneurs, if increased, could solve many problems faced by the industry and considerably reduce the reliance on foreign expertise and technology.

6. A panel should be established, comprising eminent scientists and entrepreneurs, to help provide “risk capital” to industries that are willing to exploit national researches, with a revolving fund, according to the economic conditions of the country.

7. Developing countries should develop ‘cooperative research programmes’ in area-specific subjects, based on regional/international collaboration. These programmes will include conferences, meetings, and avail of training-facilities. In particular, more than half the developing countries are actually “least developed” and still moving out from forest-based to agriculture-based economy and, therefore, S&T cooperation with developing countries could be of more use to them than with more advanced and developed countries.

8. Fifteen-year development plans, involving all the concerned stakeholders and clearly indicting the mechanisms for implementation and feed-back, should be implemented in developing countries. It is an essential pre-requisite to implement science-policy and for progress of S&T development.

9. General awareness and promotion of S&T in the general public should be increased, which will prove to be an instrument of social and economic change and increase national consciousness of real impacts of S&T in the country.

10. In the process of implementation of the S&T Policy, it is necessary to start an exercise in formulation of sectoral S&T policies, in the areas of agriculture, industry, education, communication, housing, energy, information technology, environment and other related areas. The requirement is to work within the orbit of objectives and strategies of the national Science and Technology Policy.
Human Resource Development:

11. Every country should develop sufficient manpower to fill the needs and future requirements of various economic sectors, and also for education and research. For proper development of S&T activity, it is essential that there should be a strong energetic base of highly trained and motivated S&T manpower in the various thrust areas in which rapid action is anticipated. While primary and secondary education should be broad-based and compulsory for all, college and university education should be highly selective, so that only the most talented are attracted into higher education.

12. Vocational and technical disciplines should be made compulsory at matriculation and intermediate college levels, so that after passing these stages, persons with technical knowledge are capable of earning their living and contributing to the national effort.

13. It is necessary to improve the efficiency and quality of higher education. Areas of action are (i) a clear specialization of universities and colleges by level, so that each can concentrate efficiently with the available resources, (ii) ensure autonomy to both universities and degree colleges, and (iii) increase private-sector provision of funding (scholarships, grants, etc) to higher education.

14. The S&T activity can be whole-heartedly supported by all sections of the population if it fits into the basic beliefs. So it is essential to develop “integrated curricula” at primary schools, as well as technical schools and secondary and vocational schools. At each level, books on Traditional Studies should be introduced, particularly religious views juxtaposed in context with the scientific and technological worldview.

Concluding Thoughts: Developing an effective policy for science and technology is the first step that could provide the basis, the proper context and direction to all S&T activities of a developing nation. In order to ensure sustained interest of the general public in S&T, it is necessary that people are kept regularly informed of the advances in science and technology, as well as their application: creating widespread awareness of S&T as an instrument for improving the quality of life is one of the basic aims of the S&T policy.
and, to have a successful S&T policy, the system of formulation and management of a S&T policy needs to be dynamic.

Such a system should ensure that S&T policy is formulated comprehensively, to achieve the long-term and short term objectives of national development plans. So, any change in the national priorities needs to be incorporated in the Policy.
ENERGY POLICIES FOR THIRD-WORLD COUNTRIES

1. Introduction:

It is universally recognized that energy is one of the most important inputs to economic growth and development, the consumption of energy being considered as one of the critical indicators of the level of development of any country. Developed countries use more energy per unit of economic output and far more energy per capita than developing countries. Energy-use per unit of output does decline somewhat over time in the more advanced stages of industrialization, reflecting the adoption of increasingly more efficient technologies for energy production and utilization as well as changes in the composition of economic activity. At present, over a billion people in the industrialized countries use some 60 percent of the world’s commercial energy supply, while 5 billion people living in the developing countries consume the remaining 40% – a large number of them are really poor. It is estimated that about two billion people around the world have no access to modern energy-services and as a result, struggle to meet their basic daily needs. Economic growth is the key to changing this situation, and for economic growth, energy is vital.

The energy demand is expected to increase significantly, due to fast industrial growth in the developing countries, as well as for meeting the energy-needs of the people deprived of basic necessities of life. The projection for World Energy-consumption broken up by natural resources is indicated in Figure 1. This will of course be supplemented by the development and commercialization of non-conventional sources of energy.
2. PRESENT ENERGY STATUS IN THE THIRD-WORLD COUNTRIES:

General

1. Per-capita consumption of energy is extremely low. The per-capita consumption is 14 MBtu in Pakistan, 34 M Btu for China and 92M Btu for Malaysia. For Pakistan it is estimated that the energy consumption is half of the average of all developing countries, one ninth of the world average and 1/48 of the US average. The electric power generation is much lower than the requirements.

2. Millions of villagers consume/utilize biofuels for domestic energy, causing deforestation, soil-erosion and environmental degradation.

3. Commercial energy needs and the fuels used are steadily changing as per demand, stage of development and process of industrialization. In Pakistan,

Figure 1: World Energy Consumption by Natural Resources Types 1970-2020

for example the total commercial needs are today met by Gas (49.7%), Oil (29.9%), Hydro (12.7%), Coal (6.5%), and Nuclear (0.8%), whereas in 1947 the major energy sources were 55.1% coal, 37.8% oil and 3.1% Hydro, indicating a major shift from coal towards gas and hydro power.

4. Major portion of the energy, in terms of electricity, fuel and wood, is utilized for domestic purposes: upto 48% and, in some cases, it may go to 70% depending on the stage of economic development.

5. The transmission and distribution power-losses often range between 20 and 30 per cent. Appropriate technical and administrative measures should be taken to improve efficiency of operational management. Power losses and theft are rampant in the big cities in some countries.

6. There is little effort made for energy conservation and energy efficiency in industries, agriculture and transportation and for developing integrated energy-systems for decentralized sectors.

**Nuclear and Hydro-Power etc. :**

1. Few third-world countries have nuclear power plants to supplement the energy-need. The industrialized countries are hesitant to construct, install and operate the nuclear power plants in the third-world countries, fully knowing that these plants are least polluting and are capable of providing sustainable supply of fuel and economically viable. The population in Third World countries is likely to keep growing for several decades, so the energy-demands will increase faster and hence nuclear power generation is a possible option.

2. Hydro power provides about 5% of the world’s power. Micro-hydel and mini-hydel energy generation is simple and easy to operate, but not adopted properly in the mountain-regions for want of local skills, distribution-system and billing.

3. Known technologies are available for solar pump, drying, heating, wind-energy and photo-voltaic electric generation system, etc, but not utilized /popularized due to high cost of installation, maintenance, repair and instrumentation.
To Sum-up:

1. Dozens of the Third-World Countries continue to import oil to meet the local demands at whatever costs. Pakistan imports oil to meet 90 percent of its oil-requirements and spends 60-70 per cent of total foreign-exchange earnings on it. Heavy reliance on fossil fuels, albeit limited supply and at high cost, is the major source of atmospheric concentration of toxic emissions and rising temperature of earth. Dependable and affordable supply of energy is of critical importance in order to improve/accelerate the economy and to alleviate poverty. The known energy-potential of many third-world countries is much larger than the present need of exploitation. If carefully planned and efficiently implemented and managed, this potential is sufficient to provide immediate relief to the national economy.

2. Because of the close association of energy and economic development, a basic disparity between societies is clear. Countries that can afford high levels of energy-consumption, through production or purchase, continue to expand their economies and to increase their levels of living. Those without access to energy, or those unable to afford it, see the gap between their economic prospects and those of the developed states growing ever greater.

Per-capita energy-consumption: This is a common measure of technology-advancement of nations, because it broadly correlates with per-capita income, degree of industrialization, and use of advanced technology (see Figure 2). In fact, the industrialized countries use about 10 times more energy on a per-capita basis than developing economies do. The consumption, rather than the production of energy, is the concern. Many of the highly developed countries consume large amounts of energy, but produce relatively little of it. Japan, for example, must import from abroad the energy-supplies that its domestic resource-base lacks. In contrast, many less developed countries have very high per-capita or total energy production figures but, primarily, export the resource (petroleum). Libya, Nigeria, and Brunei are a case in point.
Energy and GNP. Energy consumption rises with increasing gross national product. Because the internal-combustion engine accounts for a large share of national energy consumption, this graph is a statement both of economic development and of the role of mass transportation, automotive efficiency, and mechanization of agriculture and manufacturing in different national economies. On the graph, energy units are in gigajoules. Data from World Bank.

The advanced countries developed their economic strength through the use of cheap energy and its application to industrial processes. But energy is cheap only if immense capital-investment is made to produce it at a low cost per unit. The less advanced nations, unable to make those necessary investments or lacking domestic energy resources, use expensive animate energy or such decreasingly available fuels as firewood. The data presented in Table 1 clearly indicates that industrial countries are consuming ten times more energy per capita than the Third-World countries, where over 65% of their population is engaged in
agriculture, the main occupation of the populace, whereas only 8% of the labour force in the industrial countries is employed in agriculture.

Table 1: Economic Indicators and Agriculture’s Share of Labour

<table>
<thead>
<tr>
<th>Country Group</th>
<th>Per Capita GNP&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Per Capita Energy Consumption&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Percent of Labour Force in Agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Least Developed Countries</td>
<td>270</td>
<td>4.3</td>
<td>74</td>
</tr>
<tr>
<td>All Developing Countries</td>
<td>1250</td>
<td>855</td>
<td>61</td>
</tr>
<tr>
<td>Industrial Countries</td>
<td>20,900</td>
<td>5259</td>
<td>8</td>
</tr>
</tbody>
</table>

<sup>a</sup> U.S dollars
<sup>b</sup> Kilograms of oil equivalent; commercial energy only

*Source: World Bank and United Nations Development Programme*

3- VARIOUS SOURCE OF ENERGY AND PROJECTIONS:

**Conventional**
- Gas
- Oil
- Coal
- Hydro-energy

**Non-Conventional**
- Geothermal Energy
- Nuclear Energy
- Mini & Micro-hydel
- Solar Energy
  - Biomass Energy
  - Wind Energy
  - Wave and Tidal Energy
  - Photo-voltaic electric generation system
There are few countries in the Third World that are bestowed with conventional as well as non-conventional sources of energy. For example, Pakistan is utilizing oil, gas, coal, hydropower and nuclear power for generating electricity and utilizing it for commercial, industrial and domestic purposes. Also it has established institutions and some demonstration units to harness non-conventional sources of energy (solar, biomass, micro-hydel, wind, tidal, wave and photovoltaic solar technology). The power demand is projected to grow at an annual average rate of 7.9 per cent during the five years (2005-10) and will increase from about 15,500 MW in 2005 to 21,500 MW in 2010 (Table 2). The major demand is concentrated in industrial and domestic sectors. Various mega-projects and regulatory bodies have been approved and some are functioning in hydro-power, oil, coal, nuclear technology and renewable energy technologies to meet the power demand.

Table: 2: Estimated, Sector-Wise Power Demand in Pakistan (2005-10)

<table>
<thead>
<tr>
<th>Year</th>
<th>Domestic</th>
<th>Commercial</th>
<th>Agriculture</th>
<th>Industrial</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005-06</td>
<td>7,199</td>
<td>1,216</td>
<td>1,763</td>
<td>5,891</td>
<td>1,035</td>
<td>15,500</td>
</tr>
<tr>
<td>2006-07</td>
<td>7,585</td>
<td>1,251</td>
<td>1,820</td>
<td>6,481</td>
<td>1,086</td>
<td>16,600</td>
</tr>
<tr>
<td>2007-08</td>
<td>8,127</td>
<td>1,312</td>
<td>1,893</td>
<td>7,252</td>
<td>1,159</td>
<td>17,900</td>
</tr>
<tr>
<td>2008-09</td>
<td>8,783</td>
<td>1,354</td>
<td>1,979</td>
<td>8,181</td>
<td>1,243</td>
<td>19,600</td>
</tr>
<tr>
<td>2009-10</td>
<td>9,531</td>
<td>1,408</td>
<td>2,079</td>
<td>9,267</td>
<td>1,341</td>
<td>21,500</td>
</tr>
</tbody>
</table>

Source: Planning Commission of Pakistan

3.1: Conventional Sources of Energy

Except for the brief and localized importance of water-power at the outset of the industrial revolution, modern economic advancement has been heavily dependent on the mineral fuels: coal, petroleum, and natural gas. Also known as fossil fuels, these nonrenewable energy-sources represent the capture of the sun’s energy by plants and animals in earlier geologic times and its storage in the form of hydrocarbon compounds in sedimentary rocks within the earth’s crust. About 75% of the worlds energy-supplies presently come from these fossil fuels, barely 2 percent from hydro-power resources, 13% from biomass while about 10% of energy requirement is met from nuclear power.
Coal was the earliest in importance and is still the most plentiful of mineral fuels. Although coal is a nonrenewable resource, world supplies are so great (of the order of 10,000 billion ($10^{13}$) tons) that its resource-life expectancy is measured in centuries, not in the much shorter spans usually cited for oil and natural gas. Worldwide, the most extensive deposits are concentrated in the industrialized middle latitudes of the Northern Hemisphere (Table 3). Two countries, the United States and China, accounted in roughly equal shares for more than 50% of total world coal-output at the start of the 21st century; Russia and Germany both with large domestic reserves, together produced less than 9%. Utilization of coal for power-generation is as high as 75% in China, 54% in India and 29% in Pakistan.

Petroleum, first extracted commercially in the 1860s in both the United States and Azerbaijan, became a major power source and a primary component of the extractive industries only early in the 20th century. The rapidity of its adoption as both a favoured energy resource and a raw material important in a number of industries from plastics to fertilizers, along with the limited size and the speed of depletion of known and probable reserves, suggest that petroleum cannot continually retain its present position of importance in the energy-budget of countries. Assuming total extraction from known reserves and a constant end-of-century rate of extraction, proven reserves at these estimates would last only about 40 years. More optimistic assessments assure us that petroleum reserves that could be extracted at acceptably competitive prices would last for about 150 years at present consumption rates.
Table 3: Proved Reserves of Petroleum, Natural Gas and Coal, January 1, 2001

<table>
<thead>
<tr>
<th>Region</th>
<th>Share of Total Petroleum (%)</th>
<th>Share of Total Natural Gas (%)</th>
<th>Share of Total Coal (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Americaa</td>
<td>6.1</td>
<td>4.9</td>
<td>26.1</td>
</tr>
<tr>
<td>Europe</td>
<td>1.9</td>
<td>3.5</td>
<td>12.4</td>
</tr>
<tr>
<td>Former Soviet Union</td>
<td>6.4</td>
<td>37.8</td>
<td>23.4</td>
</tr>
<tr>
<td>Of which: Russian Fed.</td>
<td>4.6</td>
<td>32.1</td>
<td>15.9</td>
</tr>
<tr>
<td>Others</td>
<td>1.8</td>
<td>5.7</td>
<td>7.5</td>
</tr>
<tr>
<td>Africa</td>
<td>9.0</td>
<td>4.6</td>
<td>2.2</td>
</tr>
<tr>
<td>Middle Eastb</td>
<td>65.3</td>
<td>35.0</td>
<td>--</td>
</tr>
<tr>
<td>Australia/New Zealand</td>
<td>0.3</td>
<td>0.8</td>
<td>9.2</td>
</tr>
<tr>
<td>Japan</td>
<td>--</td>
<td>--</td>
<td>0.1</td>
</tr>
<tr>
<td>China</td>
<td>2.3</td>
<td>0.9</td>
<td>11.6</td>
</tr>
<tr>
<td>Other Asia Pacific</td>
<td>1.6</td>
<td>5.1</td>
<td>8.8</td>
</tr>
<tr>
<td>Total World</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Of which OPECc</td>
<td>77.8</td>
<td>44.2</td>
<td>NA</td>
</tr>
</tbody>
</table>

a: includes Canada, Mexico, U.S.A  
b: Middle East includes Arabian Peninsula, Iran, Iraq, Israel, Jordan, Lebanon, Syria  
c: OPEC: Organization of Petroleum Exporting Countries. Member nations are, by world region:  
South America: Venezuela  
Middle East: Iran, Iraq, Kuwait, Qatar, Saudi Arabia, United Arab Emirates (Abu Dhabi, Dubai, Ras-al-Khaimah, and Sharjah)  
North Africa: Nigeria  
Asia Pacific: Indonesia  


On a world basis, petroleum accounted for 47% of commercial energy in 1973, but had dropped to 40% by 2001 as a reflection of its increasing cost and of conservation measures to offset those increases. The worldwide demand for oil would rise at the rate of approx. two per cent annually between now and 2020, which means that consumption of oil will rise from 77 million barrels per day (mbd), in 2000, to 94 mbd in 2010. The price has already crossed 65 dollars. Oil shall be costly and rare due to the high demand in industrial countries and the high pace of industrialization in China and India. For instance, America being
five per cent of the world’s population consumes 25 per cent of world’s oil, and imports 60 per cent of its requirements, with little concern for depleting oil-resources. Petroleum is among the most unevenly distributed of the major resources. Seventy-five percent of proved reserves are concentrated in just 7 countries; and 83% in only 10: Iran and the Arab states of the Middle East alone control nearly two-thirds of the world total (Table - 8.3). Therefore there is great pressure on Middle East countries to share oil resources. Scarcity of oil in the near future is inevitable. Wars will be fought not over ideology but over diminishing supplies of the world’s most precious natural resources, particularly oil.

Natural gas has been called the nearly perfect energy-resource. It is a highly efficient, versatile fuel that requires little processing and is environmentally benign. Ultimately recoverable reserves, those that may be found and recovered at very much higher prices, might last another 200 years. As for coal and petroleum, reserves of natural gas are very unevenly distributed. (Table 8.3), 37.8% in former Soviet Union, 35.0% in Middle East, 7% in Africa and 5% in North America. For the world as a whole, gas consumption rose more than 60% between 1974 and 2000, to 25% of global energy consumption. The source of energy through natural gas is increasing rapidly due to escalating cost of petroleum in some developing countries.

3.2 Nuclear Energy:

Nuclear energy for power generation is considered an important alternative for the alarming rise in oil prices and dependency on foreign sources and routes. Nuclear power plants are operating in 30 countries around the world. Till 1985, 382 reactors were operating and now there are 438 nuclear plants running safely in the world. And around sixteen percent of the world’s electricity is now being generated through nuclear reactors. India had 6 reactors in 1985 and now 3 more, Pakistan had one in 1985, now one more is in operation and another one under construction. Nuclear technology can contribute significantly towards sustainable development in terms of food security, clean water, health care, pollution free environment, and reliable energy supply.

In some of the European countries, the proportion of the total electricity generated through nuclear power plant is as high as 65% (France – 65.4%, Belgium – 60.4%, Sweden – 43.4%, Switzerland – 40%). The developing countries should also endeavour to build nuclear plants having advantages, such as:
• sustainable supply and security
• compatibility with environment
• long-term economically viable
• it may spin off new technologies and business ventures.

Greater demand for nuclear power generation is envisaged in Asia particularly in China, Pakistan and India, with an eye to accelerating transaction of the base-load from oil and gas, to nuclear in view of the ——— of oil and the subsequent ——— of gas usage around 2030. Pakistan plans to increase domestic nuclear power generation from the present 430 MW to 8800MW in the next 25 years. This may appear too ambitious a target to realize. But there is no alternative. With $65/barrel, oil import costs 5 billions dollars, a burden difficult to bear.

The long-term availability of different fuels is listed below:

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uranium (once through)</td>
<td>150 years</td>
</tr>
<tr>
<td>Breeder reactor</td>
<td>1000 years</td>
</tr>
<tr>
<td>Thorium Cycle</td>
<td>Several thousand years.</td>
</tr>
<tr>
<td>Oil</td>
<td>40 years</td>
</tr>
<tr>
<td>Gas</td>
<td>60 years</td>
</tr>
<tr>
<td>Coal</td>
<td>200 years</td>
</tr>
</tbody>
</table>

It is obvious that, barring coal, no other fuel has any long-term sustainable supply. In comparing the pollutionability, the coal is most polluting, followed by oil and gas, while the nuclear energy is the least polluting, as given in Table - 6 below:

Table: 6 GHG Emissions from Electricity-Production Chains (GCeq/kWh)

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>GHG Emissions (GCeq/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear</td>
<td>2.5-5.7</td>
</tr>
<tr>
<td>Wind Power</td>
<td>2.5-13.1</td>
</tr>
<tr>
<td>Large Hydro</td>
<td>4-6</td>
</tr>
<tr>
<td>Solar PV</td>
<td>27-76</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>120-188</td>
</tr>
<tr>
<td>Oil</td>
<td>219-246</td>
</tr>
<tr>
<td>Coal</td>
<td>264-357</td>
</tr>
</tbody>
</table>
While it is correct that no new nuclear power plants were built in the United States or Britain for over 20 years, the “fear factor” linked to the accidents at Three Mile Island and Chernobyl killed the market dead. But this should not be discouragement in adopting nuclear power technology, as no other large-scale technology, world wide, has a comparable overall safety record. Also to waive off the worst effects of climate change, massive expansion in nuclear power generation is required which produces hardly any carbon dioxide. Intensification and self sufficiency in using nuclear energy for power-generation is the only immediate solution to curb the energy-deficit situation. The new breed of safer and better performing reactors marks the new era of cleaner and safer and, perhaps, cheaper energy resource. Nuclear power for meeting the energy-needs is poles apart from nuclear proliferation for weapon-use.

Thus we can see that the proportion of Nuclear Energy usage in Third-World countries also likely to increase steadily, as it has done in the developed world. In fact, the estimates for the future are that, once the use of gas has peaked (somewhere around 2030), the contribution from Nuclear Energy would begin to increase rapidly, as indicated by the inclined dotted line in the conceptual diagram from Marchetti (Fig.3). This is further supported by the fact that Nuclear power contributes directly towards sharing the base-line load in the city or area concerned.

Fig. 3: Showing the schematic representation by C. Marchetti of the rise and fall of the market shares of various energy-forms over the period from 1850 to 2100 A.D.
3.3 Renewable Energy

The fossil fuels (coal, oil and gas), beside limited reserves, have harmful effects on the environment and release toxic gases containing Sulphur, NOx, CO and heavy metals, which are great health-risk. The Kyoto Protocol (1997) directs that the Developed countries shall by 2008-2012 reduce the total emission of six key greenhouse-gases by at least 5% from the 1990 level. This is possible only if use of renewable technologies is increased substantially. In year 2000, the developing countries’ (Table 8.4) electric power capacity (1,500,000 MW) was 45% of world electric power (3,400,000 MW). World’s fossil fuels account for about two-third of generating capacity, with the remaining third being composed of large hydro (20%), nuclear (10%) and other renewable energy (3%) units. Electric Energy consumption in the developing world is increasing with economic growth and they will need to double their current generation capacity by 2020.

Table 1: Economic Indicators and Agriculture’s Share of Labour

<table>
<thead>
<tr>
<th>Technology</th>
<th>All Countries</th>
<th>Developing Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small hydropower</td>
<td>43,000</td>
<td>25,000</td>
</tr>
<tr>
<td>Biomass power</td>
<td>32,000</td>
<td>17,000</td>
</tr>
<tr>
<td>Wind Power</td>
<td>18,000</td>
<td>1,700</td>
</tr>
<tr>
<td>Geothermal power</td>
<td>8,500</td>
<td>3,900</td>
</tr>
<tr>
<td>Solar thermal power</td>
<td>350</td>
<td>0</td>
</tr>
<tr>
<td>Solar photovoltaic power (grid)</td>
<td>250</td>
<td>0</td>
</tr>
<tr>
<td>Total renewable Power capacity</td>
<td>102,000</td>
<td>48,000</td>
</tr>
<tr>
<td>Large hydropower</td>
<td>680,000</td>
<td>260,000</td>
</tr>
<tr>
<td>Total world electric power capacity</td>
<td>3,400,000</td>
<td>1,500,000</td>
</tr>
</tbody>
</table>

*Source: Renewable energy in developing countries-lessons for the market*” Renewable Energy World, July-August 2003, p.55

*Notes:*

a- Small hydro is usually defined as 10MW or less, although the definition varies by country, sometimes up to 30 MW

b- Biomass figures omit electricity from municipal solid-waste and landfill gas; commonly, biomass and waste are reported together.
3.3.1. Solar Energy:

Amongst all renewable energy resources solar energy is in great abundance, freely available, widely distributed and can easily be converted into other processes of energy. Over 1000 million people live in undeveloped economic conditions around the world between latitudes 35° N–35° S. In general greatest amount of solar energy is found in two broad bands around the earth between latitudes 15° and 35° north and south of the equator. Three approaches to the utilization of this solar energy are (a) use of low-grade heat; (b) direct conversion to electric energy; and (c) photosynthesis and biological conversion processes. Solar energy covers a wide range of applications, some are mentioned below: These are old technologies and improved upon over the ages and some are recently introduced:

- Solar room heating system
- Solar water heaters
- Solar cookers
- Solar fruit and vegetables dryer
- Solar desalination
- Solar thermal power system
- Photovoltaic (PV) power generation

Photovoltaic solar cells devices enable conversion of sun’s energy into electric power. Tremendous research in new materials as well processing technologies for the production of solar electricity has resulted in reduction in the price by two orders of magnitude during the last 30 years. Beside providing electricity, even in remote areas, PV applications are in satellite equipment, telecommunication, navigation, information technology etc. Photo-voltaic system have virtually no operational and maintenance costs. It can provide energy security without any embargoes like oil or nuclear embargo.

There is burgeoning demand for photovoltaic panels both domestically in the United States and overseas. American solar manufactures estimated that the solar market has grown 40 percent roughly in the last five years, albeit less in comparison to the Japan and Germany. Germany consumes 39 percent of all the solar panels in the world, with Japan next at 30 percent and the United States a
distant third at 9 percent. Japan had the greatest solar capacity by the end of 2004, at 1,100 Mega watts followed by Germany with 790 MW and the United States with 730 MW. However there is little response to use solar photo voltaic technology in the third world countries and the highest impediment is its cost. The average cost per kilo-watt hour is 20-40 US cents whereas that of oil, gas, thermal electric power is 3-10 cents per kilo-watt hour. In some countries steps have been taken to provide electricity through PV cells. In Kenya 20,000 small-scale PV systems have been installed since 1986 and play a prominent role in decentralized, sustainable electrification. Although efforts /initiatives were made since 1981 in Pakistan to manufacture PV Cells/panels, but with little success and confined to laboratory. PCRET has installed a number of PV systems in the areas of rural electrification, illumination, water pumps etc. The third-world countries which have abundant solar energy should develop joint ventures with firms in Japan, Germany and USA for installation and popularization of PV systems for rural electrification.

3.3.2 Biomass Energy:

The FAO estimates that wood accounts for at least 60 percent of the fuel used in the third world countries and exceeds 90 percent in the poorest countries such as Ethiopia and Nepal. Demand for fuel wood continues to grow in line with growing populations. Declining supplies are having serious human and natural consequences. Over 1.5 Billion people meet their needs only by serious depletion of wood resources upon which they totally depend, mainly living in Asia and drier regions of Africa. In parts of Tanzania and highlands of Nepal it takes 200-300 workdays to fill the yearly firewood needs of a single household. This is the energy crise of the poor. The use of wood for cooking, heating and other purposes, besides causing deforestation and environmental degradation, is also the cause of suffering to children and women due to smoke generated in the process of cooking (blindness, respiratory diseases and cancer) These countries, being mainly agriculture based, breed sufficient livestock for different purposes; and the animal waste is utilized for generation of energy. Currently all such animal waste is burned in dry form as a domestic source of energy, although it could be used for producing biogas on a community basis.
Biomass energy is obtained by converting animal and agricultural waste and Industrial processing to useful fuels, which is renewable, environmentally free and a sustainable source. Current biomass energy takes separate forms which includes distillation to produce alcohol, and fermentation to produce gases through various types of biogas digesters, which can be directly used for cooling, heating and running of power generators. Biogas technology is an option, which could offset, albeit partially, the fossil-fuel and fuel wood consumption. There are different biogas plant models and the selection depends on the geographical, economic and continued availability of waste. The various biogas uses and its requirements for different applications are as given in Table 5. The exhaust slurry of biogas plant is an enriched organic fertilizer, widely used in vegetable fields in China. Social customs, habits, prejudices, correct knowledge about the selection of model, etc. pose problems for popularization of the biogas technology.
3.3.3. Geothermal Energy:

Geothermal energy is one of the oldest forms of renewable energy with the longest industrial history. The four main sources of geothermal energy are: underground hot fluids (hydro thermal), hot dry rocks, geo-pressurized system, and (volcanic) magma; so far only hydro thermal sources are exploited. The

<table>
<thead>
<tr>
<th>Purposes</th>
<th>Specifications</th>
<th>Gas Required, (M3)</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooking</td>
<td>Per person</td>
<td>0.5 / day</td>
<td>China</td>
</tr>
<tr>
<td></td>
<td>Per person</td>
<td>0.34-0.43/day</td>
<td>India</td>
</tr>
<tr>
<td></td>
<td>Per person</td>
<td>0.425/day</td>
<td>Nepal</td>
</tr>
<tr>
<td>Gas Stove</td>
<td>5 cm dia</td>
<td>0.33/h</td>
<td></td>
</tr>
<tr>
<td>Gas Stove</td>
<td>10 cm dia</td>
<td>0.47/h</td>
<td></td>
</tr>
<tr>
<td>Boiling Water</td>
<td>15 cm dia</td>
<td>0.64/h</td>
<td></td>
</tr>
<tr>
<td>Boiling Water</td>
<td>Per gallon</td>
<td>0.28/h</td>
<td></td>
</tr>
<tr>
<td>Lighting</td>
<td>200-candle power</td>
<td>0.1/h</td>
<td>China</td>
</tr>
<tr>
<td></td>
<td>40-watt bulb</td>
<td>0.13/h</td>
<td>India</td>
</tr>
<tr>
<td></td>
<td>1-mantle</td>
<td>0.07-0.08/h</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-mantle</td>
<td>0.14/h</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3-mantle</td>
<td>0.17</td>
<td></td>
</tr>
<tr>
<td>Gasoline engine</td>
<td>Per hp</td>
<td>0.45/h</td>
<td>India (Engine efficiency 25%)</td>
</tr>
<tr>
<td></td>
<td>Per hp</td>
<td>0.41/h</td>
<td>Pakistan (Engine efficiency 28%)</td>
</tr>
<tr>
<td></td>
<td>Per hp</td>
<td>0.43/h</td>
<td>Philippines</td>
</tr>
<tr>
<td>Diesel engine</td>
<td>Per hp</td>
<td>0.45/h</td>
<td>Pakistan (Consumption ratio 20)</td>
</tr>
<tr>
<td>Generating Electricity</td>
<td>Per kWh</td>
<td>0.616/h</td>
<td></td>
</tr>
<tr>
<td>Refrigerator</td>
<td>Per m³</td>
<td>1.2/h</td>
<td>U.K</td>
</tr>
<tr>
<td>Incubator</td>
<td>Per m³</td>
<td>0.5-0.7/H</td>
<td>Nepal</td>
</tr>
<tr>
<td>Table fan</td>
<td>30 cm dia</td>
<td>0.17/h</td>
<td></td>
</tr>
<tr>
<td>Space heater</td>
<td>30 cm dia</td>
<td>0.16/h</td>
<td></td>
</tr>
</tbody>
</table>
potential geothermal energy is estimated equal to $5.0 \times 10^{12}$ Gj/year which is 12.5 times the current annual energy consumption. Presently only 0.01% of this value is being used. 39 countries have been identified that could be powered 100% geothermally, mostly in Africa, Central and South America and the Pacific, representing 620 million people. Geothermal energy with a total capacity of 15000 Megawatt is being utilized in the following manner:

1. 42% for geothermal heat pumps
2. 31% for space heating
3. 11% for bathing
4. 9% for greenhouses
5. 3% for industrial
6. 1% for agriculture

Geothermal energy is a clean renewable energy, sustainable and independent of both time and weather and operates 24 hours a day. Hence geothermal power-generating capacity needs to be increased to provide electricity.

3.3.4 Wind Energy:

This is the fastest growing renewable source of energy, with annual growth rate of 40%. This supposed to replace 10% of EU's annual electricity production by conventional source by year 2010. The total installed capacity around the world in 2001 was 24,900 MW. These are about 55000 wind-mills stalled and 70,000 people are employed in the industry globally with the investment of US$ 5 billion. The commercial viability depends on the availability of required mean wind-velocity that is 4 m/s for commercial exploitation. The wind turbine technology is fully matured and commercially viable. Cost of power generation with wind energy is quite comparable with other sources. Many modern high-speed horizontal-axis and vertical-axis machines with much higher efficiencies have been designed and are available in the market. The wind-produced electricity, can often be fed into the local or sub-network directly without any storage of energy being needed, with resulting saving of cost.
3.3.5 Tidal & Wave Energy:

Today, wave energy is only used on a small scale to power buoys, the average power-output of these systems ranges from 70 to 120 MW. Tidal power can be harnessed at specific sites, where the tidal amplitude is several meters and where the coastal topography is such as to allow the impoundment of a substantial amount of water with a manageable volume of civil works. Potential sites for Tidal Power stations have been surveyed in 25 countries, including Mauritius, China, Brazil, Chile, India, Burma and Madagascar.

3.3.6 Mini/Micro Hydro-Power:

In general, hydro-power is considered as a conventional source of energy. However small hydropower sources (less than 1MW) are now included in the list of renewable sources of energy. The technology is well developed and is effectively being used as rural energy in many countries of the world, particularly in the terrain, where natural and manageable water falls are abundantly available. For instance, in Pakistan, several sites have been identified in the northern-mountainous regions and the PCRET has installed 236 units with potential generation of 2.8 MW electricity in collaboration with the local population. Perennial waterfall is channelized and allowed to fall on the turbine from the forebay, through a penstock. In Austria there are 1690 small hydro-power plants with a total of 600 MW capacity. In Pakistan so far 290 Mini-hydel plants with local generation capacity of 4MW have been installed, electrifying about 300 villages comprising 25000 homes.

4- LUKEWARM ATTITUDE TOWARDS RENEWABLE ENERGY:

The industrialized countries are not so keen to invest in R&D for the development of renewable technologies as long the conventional sources of energy are available at the affordable cost. The Third World countries are shy even to adopt the known technologies in the renewable energy sector. Akhtar in his paper published in JSTD. Tech in 2001, gave a number of reasons for this attitude:

- lack of education and knowledge
- fear of high cost
- lack of motivation and incentives
inadequate demonstration of effective use
unavailability of suitable appliances
non-existence of proper infrastructure
trained manpower
market development and feedback services

The initiatives taken by Germany for the promotion of renewable energy and enhancing energy efficiency is worth consideration. German Chancellor and International Financial Institutions have pledged in the International Conference for Renewable Energies in June 2004, to establish a special facility with an investment of Euro 500 million for the promotion of renewable energy and enhancing energy efficiency in the developing countries. This facility includes low-interest leased loans to public and private sector institutions in the developing countries for the establishment of renewable energy projects and enhancing energy efficiency. These measures are an effort to control the rising atmospheric concentration of toxic emissions because of heavy reliance on fossil oils, particularly petroleum products. Several delegates emphasized for action oriented commitment towards the promotion of “cleaner energy” (renewable energy) to achieve goals set under the Kyoto Protocol viz-a-viz reducing toxic emissions’ level by 2008-12. The leaders pledged future investments and measures to bring sources of renewable energies – sun and wind-under use to actively demonstrate their will to combat rising temperature of earth and counter climate change. The Third World countries should come forward and avail this assistance.

5- SOME OF THE PRIORITY AREAS IN ENERGY SECTOR:

A series of conferences, seminars and workshops have been organized in recent years, both by developed as well as developing countries in cooperation with the United Nations and International Agencies/Institutions, to solve the energy problems and assist in acquiring and adopting known technologies. Some of the priority areas in the energy sector identified are:

1. energy conservation and energy efficiency in industries, agriculture, transportation and domestic use, and developing integrated energy systems for the decentralized sectors;
2. acquisition of basic nuclear technology for a self-reliant programme of nuclear power generation. In addition, increased production of nuclear energy to replace gas as it phases out after 2030.

3. research and development in renewable energy sources, including direct solar, biomass, geothermal, ocean and wind energy;

4. production of methanol and methane gas through fermentation of vegetables and animal residues;

5. technologies for coal beneficiation and converting coal into gaseous and liquid fuel;

6. developing enhanced-recovery techniques for different oil-fields, including the application of nuclear energy towards the improvement of recovery from the power sources;

7. formulate national action programmes to promote and support reforestation and national forest regeneration.

8. promote wide dissemination and commercialization of renewable energy technology-transfer mechanisms.

9. build capacity for energy planning and programme management in energy efficiency, as well as for the development, introduction and promotion of new and renewable sources of energy.

10. cooperate in identifying and developing economically viable, and environmentally sound sources to promote the availability of increased energy supplies to support sustainable development and to provide light in the homes of millions of rural population.
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