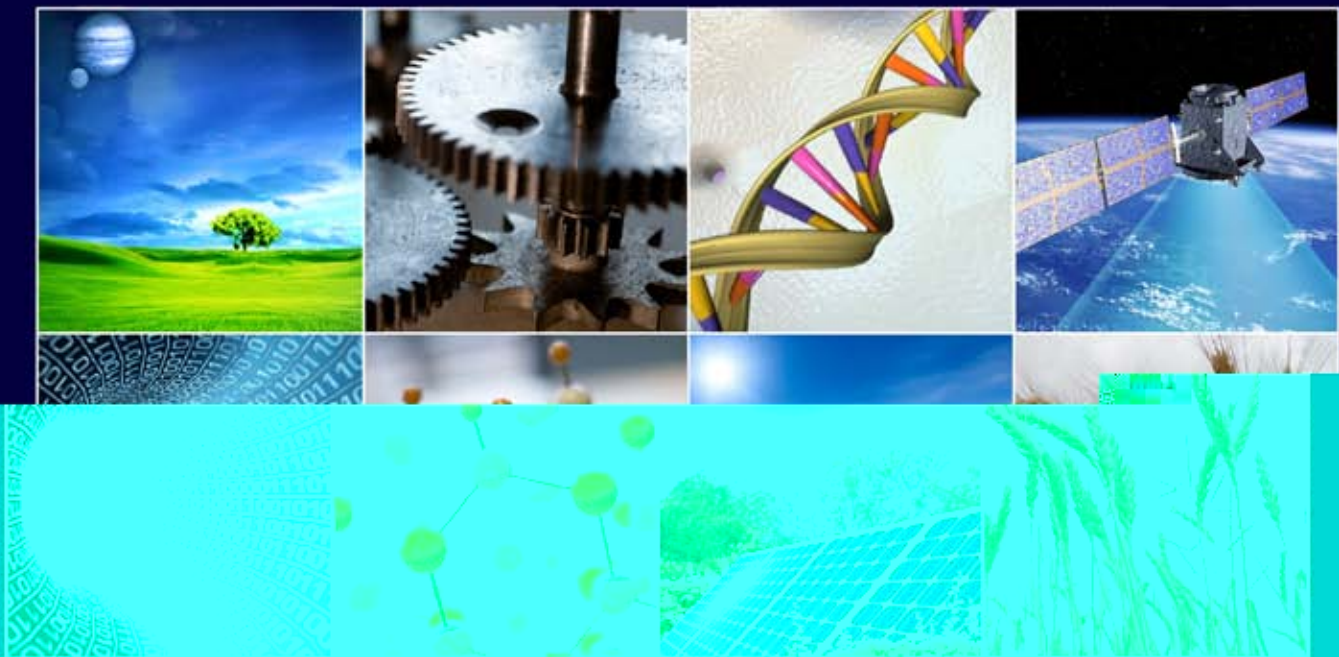


National Science, Technology and Innovation Policy 2012



October, 2012



**Ministry of Science and Technology
Government of Pakistan**

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LIST OF ACRONYMS AND ABBREVIATIONS

AJK	Azad Jammu and Kashmir	FPCCI	Federation of Pakistan Chambers of Commerce and Industry
APLAC	Asia Pacific Laboratory Accreditation Cooperation	GAVI	Global Alliance for Vaccines and Immunization
AusAID	Australian Agency for International Development	GDP	Gross Domestic Product
B	Billion	GEF	Global Environment Facility
BPS	Basic Pay Scale	GER	Gross Enrollment Ratio
BT	Billion Ton	GIK	Ghulam Ishaq Khan
CEMB	Centre of Excellence in Molecular Biology	GMP	Good Manufacturing Practice
CERN	European Organization for Nuclear Research	GPN	Global Production Networks
CIIT	COMSATS Institute of Information Technology	GPS	Global Positioning System
CMS	Compact Muon Solenoid	GSM	Global System for Mobile Communications
CNC	Computer Numerical Control	HEC	Higher Education Commission
COMSATS	Commission on Science and Technology for Sustainable Development in the South	HEJ	Hussein Ebrahim Jamal
COMSTECH	OIC Standing Committee on Scientific and Technological Cooperation	HRD	Human Resource Development
Cu	Copper	IAG	Industry Advisory Group
D-8	Developing-8 Organization for Economic Cooperation	IC	Integrated Circuit
ECNCST	Executive Committee of NCST	ICTs	Information and Communication Technologies
ECNEC	Executive Committee of the National Economic Council	ILAC	International Laboratory Accreditation Cooperation
ECO	Economic Cooperation Organization	IPR	Intellectual Property Rights
EEZ	Exclusive Economic Zone	ISO	International Organization for Standardization
EPA	Environmental Protection Agency	ISPAK	Internet Service Providers Association of Pakistan
EPI	Expanded Programme on Immunization	IST	Institute of Space Technology
FDI	Foreign Direct Investment	IT	Information Technology
		ITES	Information Technology Enabled Service
		KRL	Kahuta Research Laboratories
		LED	Light Emitting Diode
		LPG	Liquefied Petroleum Gas

Madrassah	System providing exclusively religious education	PAEC	Pakistan Atomic Energy Commission
MAF	Million Acre Feet	PARC	Pakistan Agricultural Research Council
MDG	Millennium Development Goal	PASHA	Pakistan Software Houses Association
MoITT	Ministry of Information Technology and Telecommunications	PC	Personal Computer
MoST	Ministry of Science and Technology	PCBs	Printed Circuit Boards
MoU	Memorandum of Understanding	PCRET	Pakistan Council for Renewable Energy Technologies
MP	Management Position	PCRWR	Pakistan Council for Research in Water Resources
MRA	Mutual Recognition Arrangement	PCSIR	Pakistan Council for Scientific and Industrial Research
MSTQ	Metrology, Standards, Testing and Quality	PCST	Pakistan Council for Science and Technology
MW	Megawatt	PEPC	Pakistan Environmental Protection Council
NARC	National Agricultural Research Centre	PhD	Doctor of Philosophy
NAVTEC	National Vocational & Technical Education Commission	PNAC	Pakistan National Accreditation Council
NCST	National Commission for Science and Technology	PSEB	Pakistan Software Export Board
NER	National Enrollment Ratio	PSF	Pakistan Science Foundation
NESCOM	National Engineering and Scientific Commission	PSQCA	Pakistan Standards and Quality Control Authority
NESPAK	National Engineering Services Pakistan (Pvt.) Limited	R&D	Research and Development
NIE	National Institute of Electronics	RE	Renewable Energy
NIKO	National Indigenous Knowledge Systems Office	RETs	Renewable Energy Technologies
NPSL	National Physical and Standards Laboratory	S&T	Science and Technology
NTC	National Telecommunication Corporation	SAARC	South Asian Association for Regional Cooperation
NUST	National University of Sciences and Technology	SME	Small and Medium Enterprises
OEMs	Original Equipment Manufacturers	SMT	Surface-mount Technology
		SPD	Strategic Planning Division
		SPS	Special Pay Scale
		SPS	Sanitary and Phytosanitary

ST&I	Science Technology and Innovation	UNICEF	United Nations Children's Fund
SUPARCO	Pakistan Space and Upper Atmosphere Research Commission	US	United States
TBT	Technical Barrier to Trade	USA	United States of America
TEVTA	Technical Education and Vocational Training Authority	USD	United States Dollar
TNCs	Transnational Corporations	USF	Universal Service Fund
TVET	Technical and Vocational Education and Training	Ustaad	System through which mechanics, plumbers, welders, electricians are trained in the private apprentices.
UN	United Nations	WEF	World Economic Forum
UNCLOS	UN Convention on the Law of the Sea	WHO	World Health Organization
UNESCO	United Nations Educational, Scientific and Cultural Organization	WTO	World Trade Organization

P R E F A C E

An objective analysis of the current state of Science and Technology in Pakistan leaves little doubt that this sector has not undergone systematic development during the last couple of decades. In the face of myriad exigencies emanating from political, economic and security concerns, the long-term objective of creating a strong S&T base in the country was relegated to a back-burner status. It is, therefore, not surprising that Pakistan has been unable to formulate a new S&T policy ever since the first policy document in this area was adopted in 1984.

While the world of science is witnessing breath-taking advances, which are destined to change the way people lead their lives in future, many countries of the South, including Pakistan, are feared to miss the chance of becoming a part of the global knowledge society. This is not to say that Pakistan lacks the human and material resources for being an active player in the field of modern technologies; on the contrary it has a proven potential of excellence in S&T as witnessed in the success of our strategic defense programmes. Obviously, what is required is a clear vision and well-defined road-map to put the country on course for achieving excellence in all branches of modern Science and Technology.

The Government of Pakistan is cognizant of the vital role that Science and Technology can play in the economic development of the country. This policy document reflects the desire of the present Government to put S&T at the core of national socio-economic development agenda. The role of Ministry of Science and Technology in this respect is to integrate the programmes and initiatives being undertaken by other Ministries and Departments at Federal and Provincial levels. Creating synergy and coordination between sectoral polices in health, education, industry, information technology and power production, etc. will be necessary to create a successful S&T frame-work for the country. The commitment of the Government to provide necessary legal and financial cover for the success of ST&I policy is manifested through the adoption of the policy after ensuring non-partisan political support and concurrence of provinces.

I am indebted to the Prime Minister of Pakistan for his whole-hearted support and encouragement throughout the process of adopting the policy. During the drafting phase of this document, the contributions made by the team of scientists, engineers, academicians, and members of private sector and civil society are highly appreciated. The ultimate objective of the whole exercise is to create better socio-economic conditions for all sections of our society. The success would be based primarily on the sustained commitment of the Government; however, the full and enthusiastic participation of all stake-holders, with self-less dedication and sense of responsibility towards our future generations, would be its necessary ingredients. I sincerely hope that the concerned institutions, with full support of the government, will help achieve the desired socio-economic transformation envisaged in this policy document.

(Mir Changez Khan Jamali)

Federal Minister

Ministry of Science and Technology

Government of Pakistan

FOREWORD

The process of reviewing the national S&T policy has remained stalled for many years. The first national S&T policy was approved in 1984 after lengthy deliberations extended over a period of almost nine years. Subsequently, the Ministry of Science and Technology prepared a document on 'National Technology Policy and Technology Development Action Plan' in 1993, followed by a compilation of the recommendations of 'National Commission for Science and Technology' in May 2000. The present review was started in 2009, which has culminated in a draft that is expected to provide a roadmap of projected S&T developments in the country hopefully for the next decade.

Some of the major considerations that have been kept in view for this policy proposal are as follows:

1. Considering that the objectives of previous policies have remained largely unfulfilled, a candid analysis of implementation challenges has been undertaken.
2. To bridge the gap between well-articulated intentions and tangible actions, an effective mechanism of policy oversight has been proposed.
3. Realizing the inter-sectoral nature of S&T activities, maximum effort has been made to align this policy with other approved national policies in relevant areas, such as Education, IT, Health, Environment, Water, Labour, Trade, etc.
4. For the first time, innovation is highlighted as a driver of economic activity alongside a build-up of S&T capacity.
5. A paradigm shift from supply to demand has been emphasized, with essential inter-twined roles of industry, academia and the Government.
6. The international S&T developments in recent years and the useful elements of other countries' policies have been assimilated to the extent possible.
7. It is kept in view that the common people should be the beneficiaries of all efforts envisaged under the policy, as equitably as possible.
8. Effort has been made to remain cognizant of the interests of all stake-holders, including the public sector, which is recognized as the major force behind any significant change with respect to national prosperity.

It should be well-understood that while the Ministry of S&T will be the owner of the Policy, it is by no means implied that all actionable elements of the Policy will be undertaken by the Ministry on its own. By necessity, the present document provides a holistic view of the entire landscape that is prone to actions falling under the domain of S&T in its broadest sense. Thus, education cannot be left out in the architecture of an S&T complex, yet it is understood that the players in this domain would be the relevant educational institutions. Similarly, it is repeatedly indicated in the text that the execution agents, when different than the Ministry, will be provided necessary support to achieve the overall objectives of the Policy. A prominent example is the entire gamut of engineering-based industrial activity, which has been assimilated simply by endorsing the relevant document prepared by the Planning Commission and the Higher Education Commission.

A few disclaimers with respect to the present document are also in order.

1. No attempt has been made to encompass the activities of the strategic organizations. Although, it is understood that a considerable amount of their research activity falls under the non-classified category, however, there are operational difficulties in setting up policy targets with respect to their engagements.
2. In order to avoid a protracted process of policy formulation by holding multiple conferences, establishing sub-committees, preparing green papers and organizing public debates, it was considered advisable to ascertain the interests of key organizations through consultations with senior officials.
3. The prescriptive sections under different heads have been followed by specific action lists. However, no attempt has been made to assign priority or ascertain required financial impact. It is envisaged that specific execution plans will emerge out of this document as and when sufficient financial resources are made available.

It is believed that the guidelines of this policy document can revolutionize the state of S&T in the country and its impact on society if a political will is exhibited across party lines, thereby, ensuring the continuity of the policy and un-interrupted allocation of required financial resources.

(Akhlaq Ahmad Tarar)

Federal Secretary

Ministry of Science and Technology

EXECUTIVE SUMMARY

Since its independence, in 1947, Pakistan realized the importance of science and technology for its security as well as for socio-economic development. Starting almost from scratch, it successfully installed its S&T infrastructure and established R&D organizations in almost all major disciplines of science and technology. In 1960, the National Scientific Commission of Pakistan was constituted to consider how best scientific research can be promoted and; ensured that its results are utilized for the overall development of the country. The recommendations of the Commission pave way for basic and applied research in universities and R&D institutes and laid the foundation for the S&T policy. The first “National S&T Policy” was approved in 1984 which was followed by the “National Technology Policy and Technology Development Plan - 1993”. Recommendations of the second meeting of the “National Commission for Science and Technology” held in 2000 constituted a de facto national S&T Policy till the approval of the current policy. However, despite the realization of the role of science and technology in the national development and a large number of R&D organizations and higher education institutions, contribution of science and technology in the national socio-economic development by and large remained insignificant. Under this scenario, the need for a new ST&I policy to support the social and production sector was felt by all the stakeholders that lead to the preparation of the National Science, Technology and Innovation (ST&I) Policy 2012.

The National ST&I Policy 2012 describes principal aims and objectives under the broader areas of socio-economic development, human resource development, R&D infrastructure, promotion of ST&I in the society and S&T management system and, envisages that achievement of these aims and objectives would help to realize the Vision of the policy which has been stated as “to achieve the security, prosperity and social cohesion of Pakistan through equitable and sustainable socio-economic progress using science, technology and innovation as central pillars of development in all sectors of economic activity”.

The main focus of the policy is on ST&I Planning and Management Structure, Human Resource Development, Indigenous Technology Development, Technology Transfer & Creation of Absorptive Capacity and International Cooperation as well as R&D Thrust Areas. The prominent features of the current policy are the proposal of an effective mechanism of policy oversight, highlighting innovation as a driver of economic activity, paradigm shift from supply to demand side and an effort to align ST&I policy with national policies in other economic sectors.

ST&I Planning and Management Structure

The policy identifies that due to a variety of reasons, S&T Planning and Management Structure is not functioning in an optimal manner with the result that there is a wide gap in the expectations from and the achievements of the system. The policy emphasizes that there is an urgent need to streamline the system to make it more effective and integrate it into the mainstream planning and development system. In this regard proposals have been made for the improved functioning of the following organizations which represent the important constituents of the national S&T Planning and Management System.

- National Commission for Science and Technology – Headed by the Prime Minister of Pakistan, the Commission is the highest forum for providing leadership and overall guidance in the implementation of ST&I policy.

- Ministry of Science and Technology – Main organization responsible for policy formulation and implementation.
- Pakistan Council of Science & Technology – The major organization in the country responsible for S&T policy advice to the government, to undertake research in ST&I policy, to promote quality R&D structure in the country and to monitor and evaluate ST&I policy for overall development of S&T in the country.
- It also includes that S&T Departments should be established in all the provinces.

Human Resource Development

No policy can be successful on ground unless it is demand-driven and people-centric. Therefore, in the current policy, the highest premium is placed on the quality of human resource and the necessary measures to educate and train them.

The current policy suggests the overall scheme of education and training of all categories of people at all stages of life, with separate sections on Service Conditions & Incentives for Scientific & Technical Manpower, Motivational Measures and Science Popularization. Taking a holistic view, recommendations have been made for improvement at various levels i.e. General Education of Sciences (at primary, secondary and university level), Technical & Vocational Education, In-service Training, Non-formal Education & Training and Development of highly qualified S&T Manpower.

Indigenous Technology Development

As there was no real demand from industry, the R&D system of the country is oriented towards the supply side. R&D activity in the industrial sector itself is assumed to be negligible. This is in contrast to the industrialized countries where the industrial sector is a major contributor to the overall R&D effort of the country. Realizing the urgent need, to re-orient the public sector R&D organizations to demand-driven research in collaboration with the industry, various measures for the Federal & Provincial Governments, R&D institutions and industry have been suggested in the policy for improvements in the following areas:

- High Technology
- Incentives for Development of Technology
- Technology for Socioeconomic Development
- Codification of Indigenous Knowledge
- Management of Intellectual Property Rights Regime
- Innovation Fund
- Venture Capital and Equity Fund

It is envisaged that implementation of these recommendations will enhance indigenous development of technology in the country and create R&D liaison with industry.

Technology Transfer & Creation of Absorptive Capacity

In the context of a developing country such as Pakistan, technology transfer takes place at two broad levels; international and national. International technology transfer entails the acquisition and transfer of technology from a more scientifically and technologically advanced country to a developing country. National technology transfer entails the diffusion of technology from the early leading adopters to the whole sector of production and the identification and exploitation of promising indigenous research with a commercial potential. In order for both types of transfer of technology to take place successfully in Pakistan, measures have been suggested at the individual, firm / institute and national levels particularly focusing on the following aspects of technology transfer:

- Absorptive Capacity for Technology Transfer
- Absorptive Capacity of the Firms
- University-Firm Collaboration and Scientific Mobility for Technology Transfer

International Cooperation

International cooperation plays an important role to upgrade the S&T system of any country and improve its capacity to contribute to the socio-economic development. Obviously, cooperation with industrially advanced countries is critical as it helps to improve technological capability. Cooperation with developing countries is also important as learning from the experiences of other countries at a similar level of development helps to identify best practices technologies which can be easily adopted.

The policy recommends that intensive efforts should be made to have fruitful cooperation both with developed and developing countries. In this regard suggestions have been made to materialize benefits from both bilateral and multilateral cooperation agreements and MoUs.

Thrust Areas

R&D areas have to be determined keeping in view the social, economic and security needs of the country. The National ST&I Policy 2012 has identified 16 Thrust Areas for R&D activities for Pakistan and has suggested measures for enhancing efforts in each of these areas.

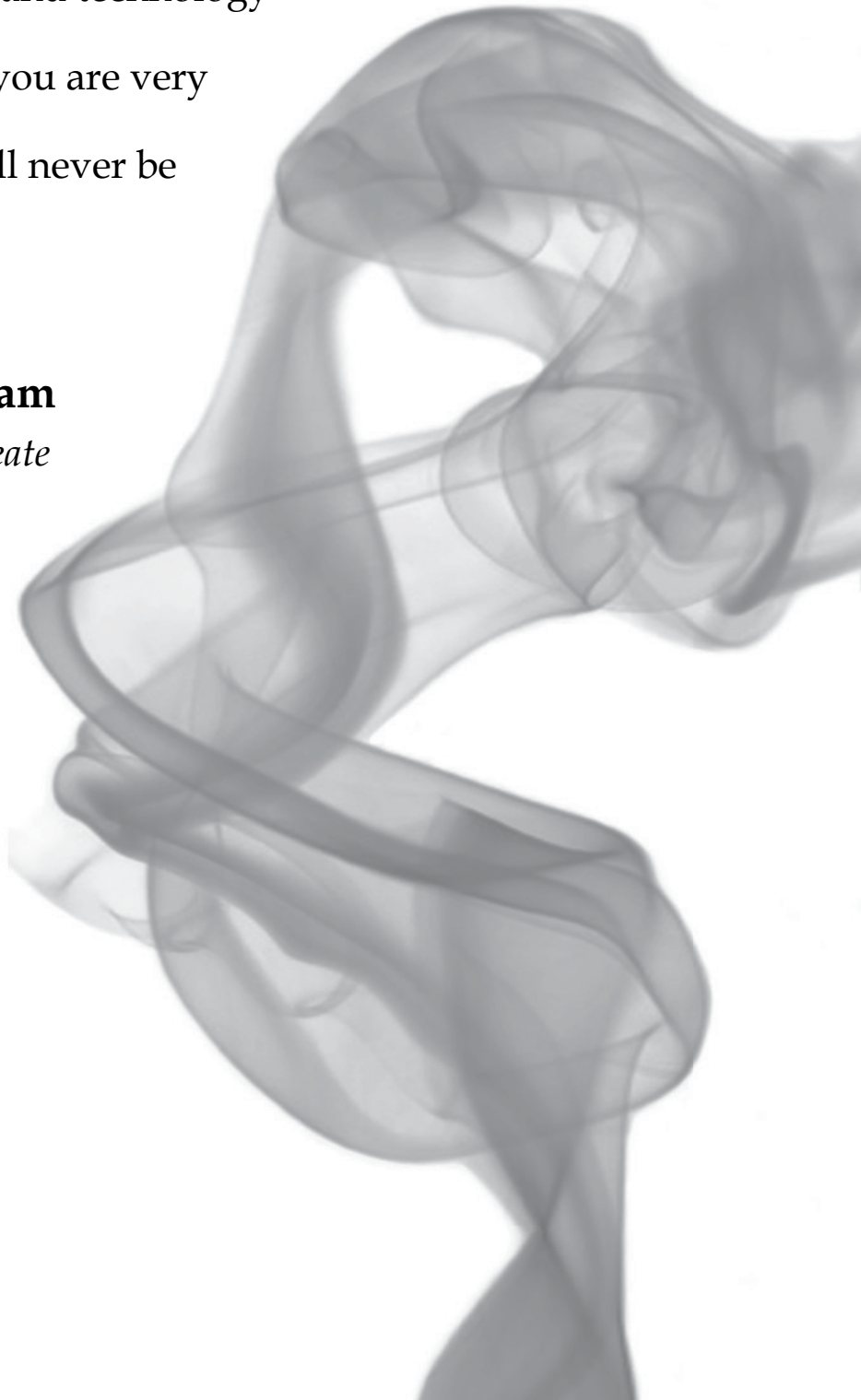
The Thrust Areas include Metrology, Standards, Testing & Quality (MSTQ), Environment, Health & Pharmaceuticals, Energy, Biotechnology & Genetic Engineering, Agriculture & Livestock, Water, Minerals, Ocean Resources, Electronics, Information & Communication Technologies (ICTs), Space Technology, Materials Science, Nanoscience & Nanotechnology, Lasers & Photonics and Engineering.

The implementation of the ST&I Policy will lead to the new dimensions in improving R&D institutions, development of research and engineering, effective collaboration between academia, R&D organizations and industry and above all economic development of the country.

“ It is just impossible to talk only of technology transfer. One should talk of science transfer first and technology transfer later... Unless you are very good at science you will never be good at technology. ”

Prof. Dr. Abdus Salam

Nobel Laureate



1. Introduction

1. It is now universally recognized that the development of a country depends on its S&T capacity. This linkage is witnessed across the nations and through the course of history of hundreds of years. Especially after the World War II, the established recipe for nation building and reconstruction has been the use of rapidly expanding S&T resources. Since the dawn of 21st century, there has been absolutely no human activity that is not affected by S&T advances, and consequently there is no socio-economic development aspect that is not prone to S&T based solutions. The transformational powers of S&T applications in changing the socio-economic conditions of any country, irrespective of its geography, ethnicity or cultural traits, are therefore self evident. Ignoring this reality can be done only at the cost of dignified national survival.

2. The pace of advances in different fields of science and technology has been steadily increasing during the last fifty years. With more countries vying for higher positions on the development ladder, the competition is becoming stronger and wider. Even the most advanced countries having pioneering role in R&D are concerned about their ability to retain their leadership positions in the long run, especially in the newly emerging fields of S&T. A prolonged and determined effort to build modern S&T capacity, through a visionary policy is the only guarantee for any developing country to achieve progress in a globalized economic world order.

3. Pakistan is a country that is endowed with all the ingredients to become an economic power but a long trail of missed opportunities has severely hampered its progress, leading to the unsatisfactory current development indicators. Historically, Pakistan performed very well in the early years after independence in 1947 and successfully installed its S&T infrastructure, starting almost from scratch. It was amongst the pioneers in developing countries to chalk-out five-year plans and to devise an impressive Science and Technology policy in

1984. The head-start of Pakistan as compared to 'Asian Tigers' came to a naught due to political instability and lack of leadership. Consequently, in spite of an impressive array of R&D organizations and higher education revival efforts, the net S&T capacity is lack-luster.

4. A comprehensive and forward looking national S&T policy of Pakistan was formulated in 1984, after an elaborate and extensive process of consultations with all relevant stakeholders. After almost 10 years, an upgrade of this policy was prepared in the form of "National Technology Policy and Technology Development Plan - 1993". An appraisal of the state of S&T in the light of existing policies was undertaken by the "National Commission for Science and Technology" in 2000. The recommendations of that meeting currently constitute a de facto national S&T Policy. No further reconsideration or revision of the current S&T system in the country took place until 2009. It is, however, relevant to mention that a number of sectoral policies such as education, health, IT, quality control, environment, industries etc, were prepared by different departments and Ministries. The national S&T system comprises of all these sectors and hence, the role of S&T policy is to create synergy, coordination and overall guidance of the integrated system. Moreover, Pakistan has a Federal political structure with considerable autonomy vested in the Provinces, which are supposed to perform a large part of actions directly relevant to the national policy. It is therefore, more important that National S&T policy provides a holistic view of the role of S&T, aligns sectoral policy objectives, plugs gaps of areas not covered by sectoral policies, sets directions of future institutional development and prescribes monitoring of the implementation process in light of clearly defined objectives. Maximum effort has been made to keep the S&T programmes aligned with the "Vision - 2030" declarations. This policy revision has also benefited from a candid analysis of the operational success or otherwise of previous policies.

5. The policy described in the present docu-

ment envisages a paradigm shift, in which innovation is recognized as an integral part of S&T system. It is emphasized that the innovation system of the country needs to be consolidated and expanded. The S&T policy has to be demand-driven and people-centric. The highest premium is placed on the quality of human resource and the necessary measures to educate and train manpower. The need to engage public sector in achieving overall policy objectives is also underscored.

6. Since, it is important that all stake-holders understand the terms Science, Technology and Innovation in a consistent manner, the commonly accepted definitions of these terms are given below:

Science is a body of knowledge about the basic principles and laws that govern the behaviour of natural world. Scientific knowledge is 'created' through observations and experimentation using deductive and inductive logic to correlate the available data. It is widely recognized that 'Science' is the basis of modern technology. No amount of technological know-how is a substitute for the ability to understand scientific prin-

ciples and capacity to expand its horizons.

Technology is the practical application of heuristic or scientific knowledge to create tools and gadgets that are helpful in a wide range of human activities. Technology provides the interface between abstract knowledge and the necessity of putting it to practical use.

Innovation is a thought process that cuts across the boundaries of S&T, involving also social, legal and financial acumen. It is a mechanism of creative thinking, making it possible to bring about positive change using all available resources. Consequently, the innovation process succeeds only in an environment where cooperative action by a network of institutions is possible. The classical definition of innovation system by Freeman (1987)[] states, ".....the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies". Innovation has strong social moorings which enable appropriate adaptation of value-neutral technical resources to achieve particular results under available conditions and constraints.

Vision & Objectives



2. Vision and Objectives

2.1 Vision

7. To achieve the security, prosperity and social cohesion of Pakistan through equitable and sustainable socio-economic progress using science, technology and innovation as central pillars of development in all sectors of economic activity.

2.2 Policy Objectives:

8. The following list of objectives is intended to be broad-based, with the understanding that the achievement of desired results would be gradual and incremental over the life-time of the policy implementation process, within the prevalent economic constraints. It is, however, premised on a major initiative of reforms and generous funding under a strong political commitment anchored in the firm belief that economic progress, social harmony and national security critically depend on our ability to master and judiciously apply modern science and technology.

9. The principal aims and objectives of the National Science, Technology and Innovation Policy of Pakistan are:

Socio-economic Development

- i. To improve the quality of life of common people in line with the parameters of Millennium Development Goals and International Human Development reports, ensuring sustainability and environmental preservation.
- ii. To create an industrial and economic environment, in which gainful employments are available to people of different abilities, enabling them and their families to lead a healthy, secure, dignified and contented life.
- iii. To make Pakistan self-reliant with respect to its strategically important needs such as energy and food, through a determined campaign of maximizing the use of indig-

enous natural resources and enhancement of agricultural produce.

- iv. To help create an S&T savvy society, through measures that create enlightenment in the masses, confidence in their ability to control their destiny, and a heightened sense
- v. of responsibility to make Pakistan a progressive and prosperous country, devoid of social ills such as religious/ethnic/gender discrimination, dishonesty, corruption, nepotism and disrespect for law.

Human Resource Development

- vi. To encourage natural inquisitiveness of young students in elementary schools and satisfy their curiosity by providing them science-based understanding of natural world. The gifted youngsters are to be identified at early stage for their possible future careers in basic and applied sciences.
- vii. To assist the educational system at secondary and tertiary level in making a transition towards 'real understanding of core scientific concepts', as compared to accretion of scientific knowledge through uncritical rote learning.
- viii. To strengthen R&D activities in Higher Educational Institutions through generous funding, availability and maintenance of experimental facilities and resources for international mobility. The encouragement of such activities can be made through financial rewards, national recognition, media exposure and high respectability in the society, creating role models and celebrities among scientific work force.
- ix. To take measures for creating a competent corps of technicians and engineers, with creative approach towards production and design in a wide range of disciplines in order to upgrade the national industrial base, capable of meeting local demands and expanding exports of products and services.

- x. To enhance skill levels at all strata of population engaged in different formal and informal sectors of economic activity through a network of training centers, continuing education facilities and in-service qualification improvement programmes.

R&D Infrastructure

- xi. To improve performance of existing R&D institutions and upgrade their field and laboratory facilities alongwith creation of new, well-equipped, multi-disciplinary research facilities at national level in areas of emerging technologies. Centralized laboratory facilities to be created to avoid duplication of expensive equipment in different organizations.
- xii. To focus on demand driven research efforts, with the objective of maximizing the use of indigenous know-how and local resources for value-added products that meet the market requirements at home and abroad.
- xiii. To make R&D careers attractive enough for the brightest students to choose Science, Technology, Engineering and Mathematics education as their highest preference. The trilogy of good salary, good research facilities and good administration is vital for satisfactory output of research workers.
- xiv. To set up institutionalized mechanism for coordination within scientific community of the country, linkage with industrial sector, and partnership with international research establishments.
- xv. To create enabling environment for innovation to flourish in small and medium enterprises in such a way that S&T based products at different levels of sophistication are developed and marketed for the benefit of common people. The innovation culture should give rise to entrepreneurship with appropriate financial arrangements.

- xvi. To give significant level of attention to basic research, which is known to provide a solid base for technological advances and to keep emerging technologies in focus, in view of their highest potential for leap-frogging in a highly competitive world.

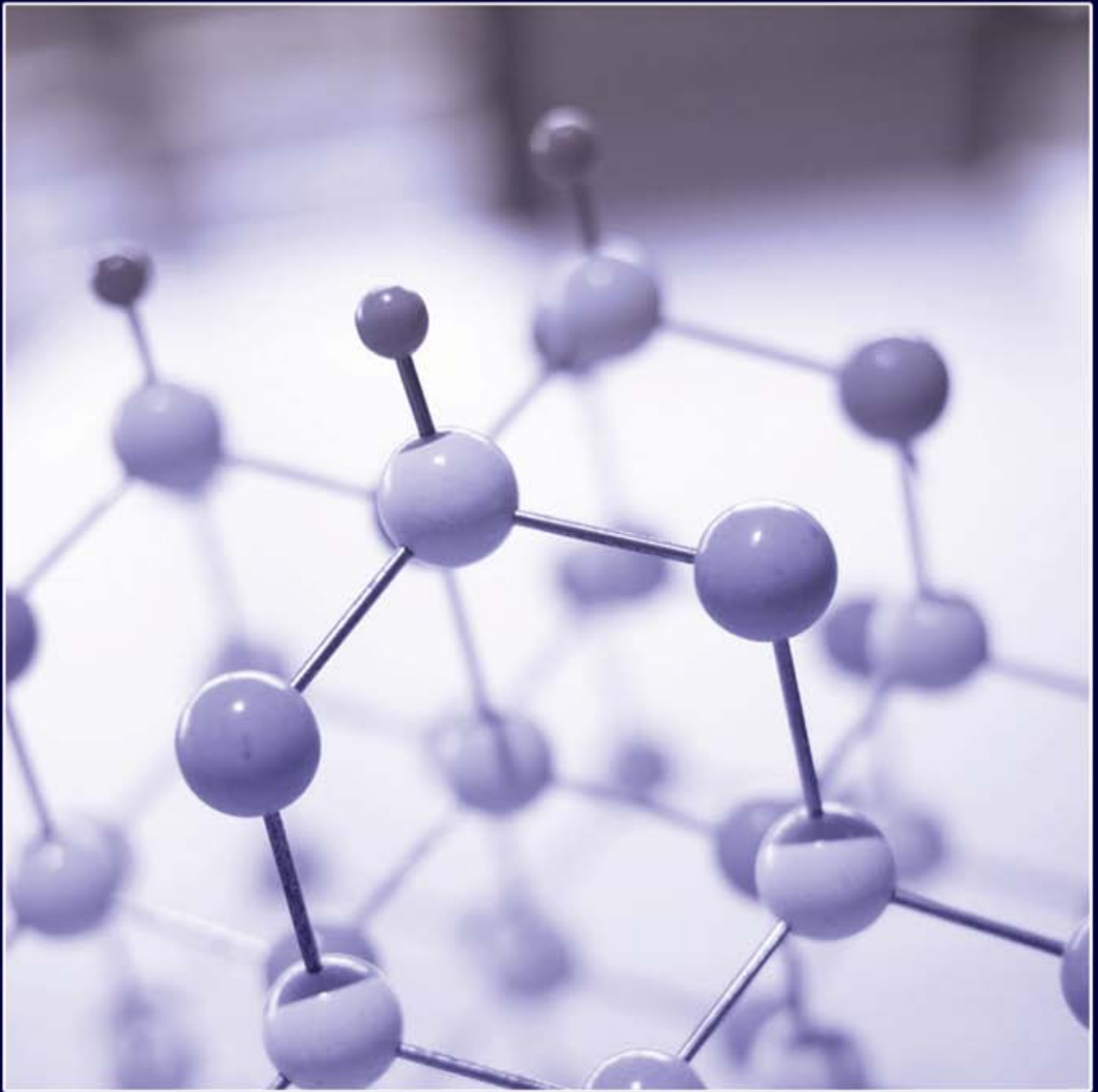
S&T Management System

- xvii. To strengthen/revamp the system of S&T policy formulation, implementation, monitoring and overall control of the sector, keeping in view the wide distribution of relevant subjects across different ministries/departments at national and provincial level and the Federal structure of Pakistan having provincial autonomy in key areas of concern for the development of S&T system.
- xviii. To devise a legally binding system for ensuring the continuity of policies, implementation of relevant decisions, enforcement of quality controls, establishment of IPR regime and other Acts, Laws and Ordinances that guarantee the robustness of the envisaged Policy Implementation framework.
- xix. To ensure that National ST&I policy has a resonance and coherence with sectoral policies that envisage the execution of major S&T based plans for conventional and renewable energy supplies, information technology access, health facilities, industrial production, environmental preservation, transport and housing projects, agro-based products and educational programmes.
- 10. To achieve the overall objectives of the policy, the following undertakings are envisaged:

Policy Actions:

- A1. Declaration of the political will that S&T capacity building would be a central pillar of national development strategy and the R&D expenditure would be enhanced to 1.0% of GDP by 2015 and 2.0% by 2020.
- A2. Commitment to create a long-term non-partisan ST&I policy with the consensus of all stake-holders and putting in place a legal framework for ensuring continuity of the policy and allocation of required funds.
- A3. Issuing the guidelines for shifting the focus of R&D towards demand side with full participation of private sector and employing mechanisms to foster innovation.

ST&I Planning and Management Structure



3. ST&I Planning and Management Structure

11. The existing planning and management structure for non-strategic

Science and Technology sector comprises:

- The National Commission for Science and Technology (NCST)
- The Executive Committee of NCST (EC-NCST)
- Ministry of Science and Technology (MoST)
- Pakistan Council for Science and Technology (PCST)
- Provincial Departments of Science & Technology, Planning & Development

12. Due to a variety of reasons, this structure is not functioning in an optimal manner with the result that there is a wide gap in the expectations from and the achievements of the system. The S&T system is currently functioning more or less in isolation from the industrial sector as well as the economic and social development plans of the Government. There is, therefore, an urgent need to streamline the system to make it more effective and integrate the S&T system into the mainstream planning and development system.

13. The National Commission for Science and Technology (NCST) was created under a Resolution of the Ministry of Science and Technology with Gazette Notification of April 1984, as a part of the implementation of the National S&T Policy (1984). It was envisaged that with the Prime Minister as its Chairman, it would be the apex decision making and coordinating agency for S&T in the country, to “provide leadership and overall guidance in the development of a strong, well-integrated system of science and technology and its deployment for rapid socio-economic progress”. Its major achievement has been the approval, in principle, of the recommendations of the 2nd meeting held on 2nd May 2000, which are at present serving as the

de facto S&T Policy/Action Plan. Originally MoST was the secretariat of NCST, but in 1997 this function was assigned to PCST.

3.1 National Commission for Science and Technology (NCST)

14. As a result of the 18th amendment in the Constitution, some federal ministries have been devolved while some new ministries / divisions have been created and a few others have been renamed. Further, some functions i.e. Education, Health, Agriculture etc. have been transferred to the provinces. Therefore, for effective representation from all stakeholders, composition of the NCST needs to be revised. The composition of Executive Committee of NCST also needs to be revised.

3.2 Ministry of Science and Technology (MoST)

15. The Constitution of Pakistan (1973) defines the S&T research coordination as the responsibility of the Federal Government. Consequently, the Ministry of Science and Technology was created and its Rules of Business were approved in 1973. The Ministry is, therefore, the rightful owner of National ST&I policy and primary agency for the implementation of this policy. The enhancement of provincial autonomy under the 18th amendment (April 8, 2010) does not curtail the Ministry’s role and functions.

16. In addition to its functions under the “Rules of Business 1973”, the Ministry of Science and Technology may perform the following functions:

- i. To execute necessary actions or cause to get these actions done in implementation of the national ST&I Policy.
- ii. To prepare feasibility studies of projects under the ST&I Policy and submit financial allocation requests for the development of S&T in line with ST&I policy on yearly basis.
- iii. To formulate proposals for national cent-

ers where R&D equipment for multi-disciplinary research is accessible to all researchers.

- iv. To significantly enhance the research funding role of PSF in direct support of projects, which have been thoroughly vetted by experts and deemed to have significant effect on national economy.
- v. To make preparations for setting up and maintaining at least one major Technology Park in each Province, AJK, Gilgit Baltistan and the Capital territory to be attached to selected universities.
- vi. To coordinate between S&T organizations and the production sector.
- vii. To coordinate with the Planning Commission for translating the S&T requirements of the national development plans into well-defined programmes and assigning them to the appropriate R&D agencies for execution.
- viii. To plan and execute programmes for the specialized HRD requirements of its organizations.
- ix. To function as the principal agency for international liaison in Science and Technology.
- x. To perform technical audit of the S&T organizations under MoST with respect to the provision of financial /material and human resources.

To perform these functions, the technical wings of the Ministry needs to be adequately strengthened.

3.3 Pakistan Council for Science and Technology (PCST)

17. The creation of Pakistan Council for Science and Technology in 1961 was a major step forward to institutionalize the monitoring of S&T development in the country and to undertake foresight exercises for future policy direction. It has been acting as a secretariat of NCST,

scientific data collection centre, and S&T policy advice think tank, encouraging high performance in S&T workers through cash awards, promoting international cooperation and publishing reports and reviews on the state of S&T in Pakistan. The role assigned to PCST is indeed highly relevant and enormously significant. The human and financial sources put at the disposal of PCST, however, do not match with the achievements expected from this organization.

18. It is, therefore, of paramount importance that PCST is strengthened and its role enhanced through the following measures:

- i. PCST should be recognized as an autonomous body under the Ministry of Science and Technology with its statutes approved through an act of Parliament.
- ii. A special wing of PCST should be created with a qualified team of S&T Policy experts to undertake research in policy related issues on continued basis, so that periodic S&T policy reviews can be undertaken without starting the process ab initio.
- iii. PCST should be provided adequate funds and human resources to perform its present functions, listed below, in a more efficient way.
 - (a) To advise the Federal Government on all matters pertaining to the development of science and technology in country.
 - (b) To undertake policy research, organize study groups/task forces, formulate policy proposals, monitoring and evaluation of S&T policy for achieving targets for the overall development of science and technology in the country.
 - (c) To identify priority areas for research and development keeping in view the futuristic developments of science and technology.
 - (d) To constitute expert committees in various disciplines for preparation of

reports on policies and issues of national importance in respect of science and technology.

- (e) To act as the secretariat for National Commission on Science and Technology (NCST).
- (f) To collect, update statistics and maintain database on science and technology potentials of the country.
- (g) To take measures for effective collaboration between academia, R&D organizations and industry for development of indigenous products / technologies.
- (h) To promote quality R&D culture in the country, evaluation of national research and development activities including output of individuals and institutions and to grant awards/ incentives thereof.
- (i) To promote collaboration among national and international organizations for promotion and capacity building in science and technology and to enter into MoUs, contracts etc.
- (j) To participate in national science and technology planning and development activities and providing advice on selection of projects.
- (k) To promote or implement projects of national importance.
- (l) Any other function assigned by the Federal Government.

3.4 Provincial Departments of Science and Technology

19. The major part of productive activity in industrial and agriculture sector is necessary at the provincial level. The execution of development projects as well as the conservation and sustainable use of natural resources is mainly the responsibility of the provinces. Moreover the results of R&D effort especially in the fields

of agriculture, health and industry have to be utilized by different agencies of the Provincial Governments. The Khyber Pakhtunkhwa Government has already set up a Department of Science and Technology, an example to be emulated by other Provincial Governments[]. In addition to their province specific roles, these Departments may also serve as the focal point for:

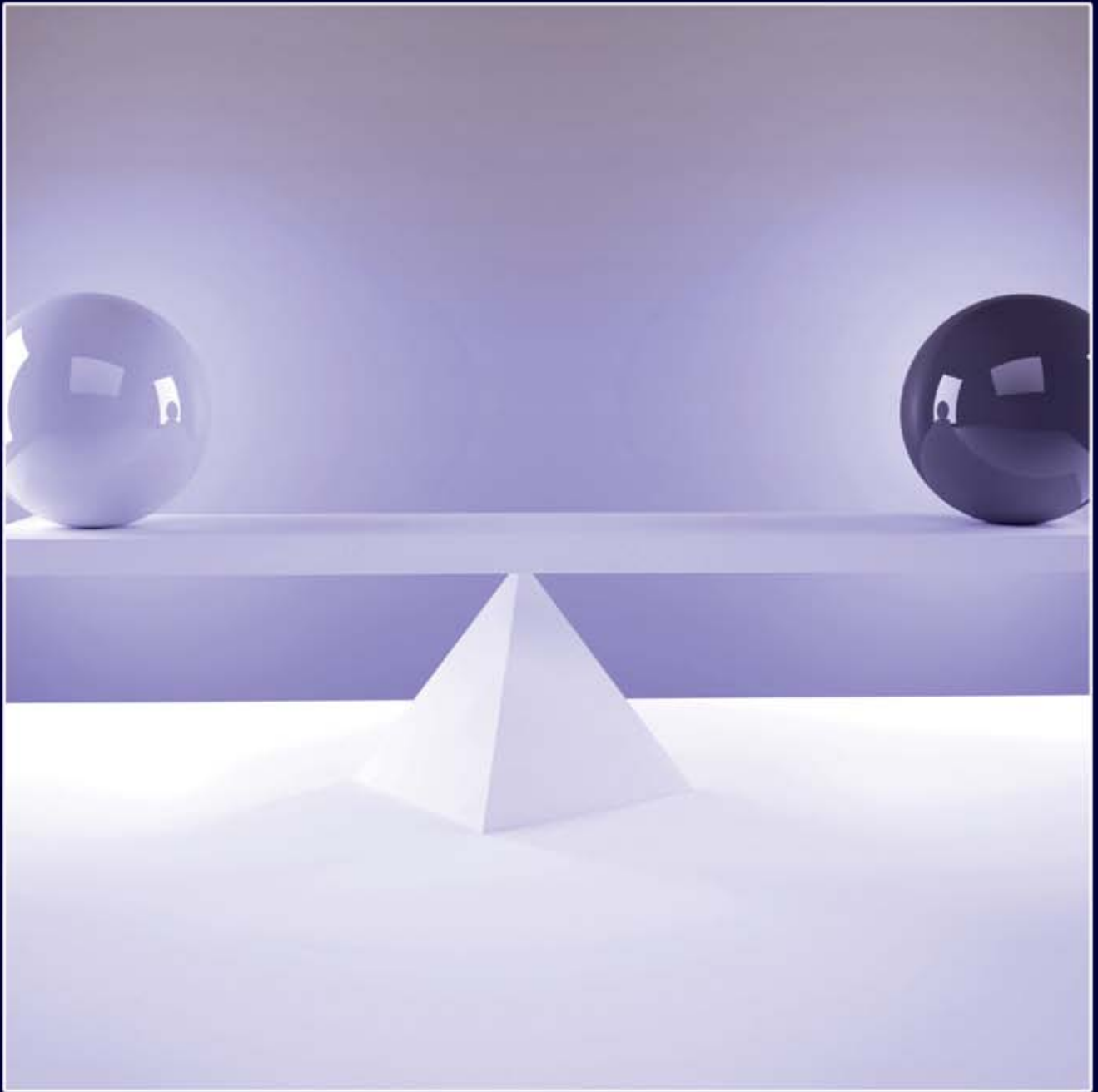
- i. Communication with PCST and the Federal Ministry of Science and Technology.
- ii. Planning and implementation of coordinated inter-disciplinary and inter-departmental S&T programmes at the provincial level.
- iii. Creation of site-specific technologies appropriate to the needs of various areas depending on the local conditions and natural resources.
- iv. Prompt and effective dissemination of research results to the end users.

20. The institutional reforms pertinent to formulation, execution and monitoring of the policy implementation will be carried out with the help of following actions:

Policy Actions:

- A4. Re-composition of NCST and ECNCST.
- A5. The establishment of PCST as an autonomous body through an Act of Parliament.
- A6. Establishment of a well-staffed ST&I Policy cell in PCST.
- A7. Coordination with the Provincial Governments to establish and operationalize provincial Departments of Science and Technology.
- A8. Strengthening of Technical Wings in the Ministry of Science and Technology for evaluation and monitoring of R&D activities.

Human Resources



4. Human Resources

21. Development of human resources is the most important aspect of any science and technology policy, as without an adequate number of well trained scientific and technical manpower at all levels (i.e. researchers and technicians) any investment in buildings and equipment would be counterproductive. While the technically advanced nations have researchers in the range of 2,000 to 5,000 per million population, Pakistan has only 162[]. The position of the technician level manpower is similarly inadequate i.e. 64 technicians per million[], as compared to 1500-2500 in advanced countries. In order to address the issue of creating an S&T workforce, which is well-qualified, appropriately trained, motivated, disciplined, quality conscious and endowed with a strong sense of responsibility towards their assignments, it is necessary to take a holistic view of all phases of human intellectual development. Scientific training essentially starts right from the cradle when the child starts picking up the cause - effect relationships. The process should transform into a scientific 'attitude', whereby rational and analytical approach becomes a habit of mind. Coupled with ethical standards, such as honesty, truth, consciousness of one's rights and obligations, and respect for law; a body of people can naturally grow to become a strong, prosperous, civilized society. Therefore, ST&I policy has to prescribe measures that influence the growth of a child right from home and through the entire ensuing life as a responsible and productive citizen.

22. In the following sections, the overall scheme of education and training of all categories of people at all stages of life is considered, with separate sections on S&T service structures, working conditions and motivational measures for their optimal performance. Creating a mind-set in which innovation and assimilation of technology occurs naturally and any achievements in this respect are revered by the society, is a task that would have to be implemented through a variety of means over a period of decades. The social status and financial

rewards attached with any field of activity are the natural attractors for manpower build-up in that sphere. The opportunities provided and incentives given to selected individuals with inherent aptitude, level of intelligence and abilities would inevitably create a large pool of required manpower out of a huge young population group, which in Pakistan is at a level of about 50% below the age of 20.

4.1 Education and Training

23. The present policy endorses the vision adopted in the "National Education Policy - 2009"; states "our education system must provide quality education to our children and youth to enable them to realize their individual potential and contribute to development of society and nation, creating a sense of Pakistani nationhood, the concepts of tolerance, social justice, democracy, their regional and local culture and history based on the basic ideology enunciated in the Constitution of the Islamic Republic of Pakistan". It also takes note of the observations made in the said policy document (part of para 34). "On the Education Development Index, which combines all educational access measures, Pakistan lies at the bottom with Bangladesh and is considerably lower than Sri Lanka. A similar picture emerges from the gross enrollment ratios that combine all education sectors and by the adult literacy rate measures." To address specific aspects of each phase of education, learning and special trainings, this category is further divided into different groups as discussed in the following subsections.

4.1.1 General Education of Sciences

24. Scientific and technical talent has to be nurtured from a very young age. Starting from the primary school, where the pupils need to be introduced to study of nature, through the secondary school, where more emphasis is needed on 'doing science' rather than 'learning science' through passive absorption of information. At the end of school education the students should have a basic understanding of science and how its principles affect their daily

lives, instead of the current rote learning and reproduction in the examinations. The University education has to be geared towards producing confident, capable and creative graduates.

Primary level

25. The evaluation of the current situation in the primary level education category has been reported by the National Education Policy - 2009 in the following words. "Despite some progress in recent years access rates remain low,.....", "Net Enrollment Ratio [NER] at 66% for primary education are the lowest compared to the selected reference countries. The survival rate to Grade 5 is 72%". Of most concern are the facilities available to young pupil and the quality of education imparted, especially with reference to science, environment, sanitation and social responsibility. A child who is unaware of the significance of personal hygiene, cleanliness of environment in home, school and public places, responsible use of resources such as water and electricity, is most likely to behave like an 'illiterate' in spite of the certificates of 'qualifications' indicating otherwise. The State's responsibility in this connection is to provide sufficient number of schools with adequate facilities, enough teachers who know the significance of the foundational role played by them in creating future citizens of Pakistan, and syllabi that encourage and enhance natural curiosity of young minds.

26. Some of the policy elements for early S&T education are listed below:

- i. The syllabi for science at junior school levels will be reviewed in consultation with the federal and provincial education organizations / departments. The focus of the syllabi will be to initiate thinking process among students and create interest in things around them and help understand these on scientific basis. To ensure this, curricula development committee will be constituted at provincial/regional levels headed by the faculty members of the higher education institutions in the province/region and selected teachers from junior and senior schools. Ministry of Science and Technology in collaboration with the federal and provincial education organizations / departments will organize a review of these curricula by foreign experts.
- ii. Ministry of Science and Technology in collaboration with the federal and provincial education organizations / departments will develop a training programme for junior school teachers on 'how to teach science'. In the initial phase, master trainers will be trained at the education departments of the national universities by arranging the national and foreign resource persons. In the second phase, the master trainers will be assigned the responsibilities to train the school teachers at the district level. The training will be open to all junior school teachers and will be mandatory.
- iii. In schools, students will be encouraged to participate in the creative activities relevant to science and their work will be displayed in the class rooms to give them confidence. At school level, an exhibition will be arranged annually showing the creative work of the students. Provincial Education Departments will ensure availability of funds for provision of necessary items and material for this purpose.
- iv. A visit to nearby science museum and an institution of higher education for the students will be arranged once in a year to generate sustained interest among the school students.
- v. Availability of small story books written in a manner to demonstrate some scientific aspect of every day life will also create interest among students. Ministry of Science and Technology in collaboration with National Book Foundation may help either to encourage writing of new books by the local authors or to re-publish/translate the already available books.

vi. While noting that almost one-third of primary school age children remain out of school, the National Education Policy has a target of 100% enrollment by 2015. The additional emphasis that ST&I policy should provide is that the students should have imbibed the qualities of inquisitiveness, cleanliness and discipline.

27. The minimal actions required to implement this policy are as follows:

Policy Actions:

- A9. Review of syllabi for science at primary level with emphasis accorded to development of creative thinking and problem solving skills.
- A10. Enhancement of teachers' skills and approaches concerning 'how to teach science'.
- A11. Motivational programmes for students to engage in creative activities.
- A12. Schemes for invoking interest in science and acquisition of relevant knowledge at the very early age.

Secondary and Higher Secondary Education

28. At the Secondary and Higher Secondary Education, the students develop interests or otherwise in scientific disciplines depending on how scientific subjects are taught and the level of interest that these studies generate. In the National Education Policy, 2009 it is noted that, "the secondary and higher secondary school system prepares young people for life. It has two important roles in this respect; in providing skills to the labour market, as many students leave formal schooling at this time, and start providing input to the tertiary system. The system does not provide an adequate base for both these functions. The disadvantage of the rural area at the secondary level GER (Gross Enrollment Ratio) is rather large: (48% urban versus 22% rural in both 2005-06 and 2007-08)". This is also the period when students make decisions about their career choices. This decision

is influenced by:

- i. The natural interest of the student in a particular subject/field.
- ii. The prospects of a good career with a salary that would provide reasonable financial security to them and their families.
- iii. The quality of teaching faculty, while a good teacher can inspire a student, a bad or indifferent teacher can actually drive a student away from a particular subject.

29. In order to attract the best students, it is imperative that careers in science and technology, especially teaching and research, are made as attractive as other subjects such as business administration. While the Tenure Track system introduced recently by HEC in public sector universities has succeeded in attracting students to a career in teaching, the BPS system of salaries prevalent in the public sector R&D organizations has failed to attract good quality manpower to a career in research. The availability of well-equipped science laboratories and libraries is a prerequisite for science teaching at this level.

30. For improving the quality of teaching, the in-service training of college teachers should focus not only on their knowledge of the subject but also on the methods of transferring that knowledge to their students. Further, science based extra-curricular activities in college would also keep the interest of students alive in a career in S&T rather than business administration, or other subjects. On the average, science teachers in colleges spend more time on teaching than their colleagues in humanities or social sciences. It is, therefore, justified that they should receive an additional Science Teaching Allowance as compared to their colleagues.

31. The policy elements required at this level of education are:

- i. The curricula for science subjects at secondary and higher secondary levels will be developed in consultation with the federal

- and provincial education organizations / departments. To ensure that curricula are at par with any developed countries, consultation of foreign subject specialists will be acquired.
- ii. The low-availability of qualified and trained science teachers is the major constraint for imparting quality science education in schools. The problem is more pronounced in schools situated in rural and remote localities. The available science teachers prefer to stay in urban areas mainly due to opportunities for private coaching of students after school hours. To overcome the shortage of qualified teachers, the science teaching profession needs to be made more attractive for the youth through better service structures. Introduction of 'science teaching allowance' equivalent to 50% of the basic salary may help to attract more youth to adopt science teaching. Similarly, teachers working in rural and remote areas need to be compensated with allowance to the same tune.
 - iii. Capacity development programmes for science teachers will help refresh their knowledge and learn new teaching methods. For this purpose, basic sciences departments and the education departments of the selected universities will be motivated to initiate short professional development courses for science teachers in summer and winter vacations. Ministry of Science and Technology will frame a comprehensive training programme in consultation with the federal and provincial education organizations / departments and local universities. Foreign training programme for science teachers will also be initiated in collaboration with Higher Education Commission and foreign partners such as US Education Foundation, AusAID etc.
 - iv. It has been observed that most of the secondary and higher secondary schools do not possess adequate and good quality laboratory facilities. There are no hands-on experimentation facilities for students. The provincial education departments will ensure modest funding for provision of scientific instruments and consumables. Ministry of Science and Technology will develop minimum requirement for laboratories in the science subjects to help provincial departments to establish such labs. Ministry of Science and Technology may initiate one-time grants for development of lab facilities in remote and less developed areas.
 - v. Presently, there is no mechanism for helping students to make decision about the choice of their careers in science. The entrance in higher secondary level education is a crucial period for the students to decide their educational path which ultimately leads to their future careers. In the cosmopolitan environment, the urban students have more exposure to the information and are networked as compared to students in remote areas. Establishment of student counseling offices at district level and the periodic visits of the counseling staff to secondary schools will help the students to select appropriate science disciplines, keeping in view the students' natural interest in a particular field, prospects of a good career, job opportunities, and financial security etc.
 - vi. The universities and higher education institutions need to come forward to help local communities to promote education. Universities usually have qualified faculty in various science disciplines who may help in improving standard of science teaching at school level. Their involvement in curricula development, teachers' training, establishing lab facilities, delivering lectures at schools on specific topics, inviting school students to visit university and science labs will help impart quality education and inspire the students. The donation of relatively outdated IT equipment such as projectors, multimedia, computers and lab equipment to schools will provide

better utilization of these items rather than dumping.

32. Some of The proposed actions are:

Policy Actions:

- A13. Development of the curricula at secondary and higher secondary levels in such a manner as to increase interest in science and technology among the students.
- A14. Ensuring the availability of qualified and trained teachers at secondary and higher secondary schools for teaching of science subjects.
- A15. Provision of fully equipped science laboratories at schools to demonstrate the curricula related experiments.
- A16. Devising counseling programme for students to help select the science subject more appropriate to their aptitude.

University Education

33. By joining a university degree programme a student is already committed to pursue a chosen career. At that stage, it is the responsibility of the University to prepare the students for their intended job markets. Specifically, in scientific and engineering disciplines, a university graduate must have a pedagogical command on the subject, and also developed creativity, innovation and problem-solving traits.

34. Our universities need to function as centers for creation of new knowledge and not just as degree awarding institutions. Besides producing competent engineers, doctors, architects etc. for the job market, the universities need to produce research scientists capable of working at the leading edge of science. University students' design and innovation skills will be polished by providing industrial exposure through industrial trainings that will help them better understand the industrial processes and will provide a firm base for research. The Universities/Institutes of higher learning will be

encouraged to actively participate in the technology parks in order to develop skills related to product design, invention, innovation, adaptation, and technological reproduction. The programmes and initiatives of the Higher Education Commission for the production of high-level manpower, both locally and in foreign universities, are expected to yield dividends in the shape of availability of a large number of PhDs in the near future. This will help to alleviate the present acute shortage of good quality S&T manpower both in the universities and research organizations. However, the current stress on quantity should increasingly be replaced by emphasis on quality. Further, at present, the doctoral programmes are random and lack long-term commitment, as they are being implemented as development projects. These should gradually be replaced by a National PhD Scholarship Programme to cater for an assured and regular supply of highly trained manpower. In addition to a local component, this programme should have a foreign component for training of scientists in new and emerging fields where the local capacity needs to be built or strengthened. Mechanisms for lifelong learning and in-service continuation of education should also be strengthened.

35. While the research organizations will also benefit from the manpower trained under HEC programmes, the relatively large public sector R&D organizations, such as PARC, PCSIR etc. should have their own, targeted programmes for HRD as per their own requirements. This would ideally be in the shape of PhD scholarships for new entrants as well as postdoctoral training in specific, pre-determined areas for their existing employees. This approach, adopted in the early years of establishment of PAEC, provided a relatively large body of well-trained manpower that was used not only for PAEC, but also for establishing other institutions such as Quaid-e-Azam University, KRL, NESCOM etc. A mega project "Strengthening of HRD in MoST and its Organizations- Development of 400 PhDs" submitted by PCSIR has already been approved by ECNEC in February 2008 with cost of Rs. 2898.98 million and 08 years

duration. The Project has provision for the development of 400 PhDs and 200 Post Doctoral Fellowship for S&T organizations. The project has not been launched yet and should be implemented at high priority.

36. The Higher Education system should be in line with the worldwide paradigm shift from “Teaching” to “Learning”, programmes of study ensuring maximal absorption of subject matter by the students. Changing innovation processes and evolution of the relative contribution made by the private and public sectors have emphasized the need for strong industry-university linkages, allowing both sectors to interact and collaborate on joint projects. Higher education sector is a major force for innovation. Universities and colleges through local, regional, national and international partnerships must share their expertise and facilities to support socio-economic regeneration and growth. Movement in the global knowledge-society would require universities to develop into diverse, self-analytical and adaptable enterprises. Only a sector that is actively engaged in meeting the needs of its stakeholders would be adequately prepared to respond to the accelerated pace of change the global markets would inevitably undergo in the 21st century.

37. Policy initiatives that need to be taken to make higher education well aligned with the national productivity and innovation are given below:

i. Presently, 5.1% of the youth between the age of 17-23 years have access to higher education in Pakistan. A good percentage of students start their educational programmes in the engineering and science disciplines but very few end up with higher degrees and choose careers in scientific research. Most of the universities function as degree awarding institutions rather than centres for creation of new knowledge. There is a need to expand the access to higher education to fully capitalize the potential of our predominantly young population. As targeted in National Education Policy 2009, steps shall be taken

to raise enrolment in higher education sector from existing 4.7% to 10% by 2015 and 15% by 2020. Investment in higher education shall be increased to 20% of the education budget along with an enhancement of the total education budget to 7% of GDP. [National Education Policy, 2009].

- ii. Higher Education Commission has initiated the human resource development programme by sending scholars in technologically advanced countries for PhD programmes and also developed the indigenous capacity of the national universities by encouraging the scholars to enroll in research degrees locally. Presently, about 10,000 scholars are enrolled in PhD degree programmes both within the country and abroad. The human resource development programme needs to be continued through the provision of scholarships. A split research degree programme (2 years in local university and 2 years in foreign university) or dual degree programme with full local tuition will be encouraged.
- iii. Ministry of Science and Technology and Higher Education Commission will help develop specialized laboratories in research and education institutions around a cluster of professionals like the Korean and Japanese model in which each senior researcher has his/her own specialized lab and a group of researchers.
- iv. Higher Education Commission has launched digital library programme which provides access to 75,000 number of electronic content. The access will be provided to all the research and scientific organizations to better utilize the facilities.
- v. An attractive career will be offered to the scientists and engineers by offering Special Pay Scales or Tenure Track System in research and educational institutions. The promotion formula for the scientists and engineers will be based on the weightings of research publications, patents, length of service etc. and scientists and engineers

- will be categorized as S1, S2 and E1, E2 after achieving a predefined quantitative levels. The remuneration of the scientists and engineers will be fixed according to the categories.
- vi. Expatriate Pakistani engineers and scientists working abroad will be encouraged to work in national research and educational institutions. An attractive salary package will be offered along with the research facilities for these professionals.
 - vii. Scientists and engineers will be encouraged by awarding prizes for their achievements annually. A list covering all the scientific disciplines ranging from natural sciences to physical sciences will be developed to encourage professionals in all scientific disciplines, e.g. Natural Sciences Prize, Technological Invention Prize, Science and Technology Progress Prize, and International Science and Technology Cooperation Prize.
 - viii. A balance between the basic and applied research will be developed to help encourage the creation of new knowledge and marketable technologies.
 - ix. Techno-entrepreneurship is lacking in national research and educational institutions at present. The main constraint in its development is tendency of the individual and private sector to be reluctant to take the risk. This can be promoted by sharing the risk. Technology Incubation and Business Development centres in research and educational institutions will be set up to promote the applied research and also provide a platform for the young entrepreneurs.

38. Some of the practical measures to realize these objectives are as follows:

Policy Actions:

- A17. Access to scientific, engineering and technical higher education to be increased by enhancing the existing facili-

ties and establishing new institutions.

- A18. The quality of education to be enhanced through provision of qualified faculty, up-gradation of labs, and access to scientific information.
- A19. Attracting talented students with an aptitude for research by providing assured career opportunities in academia, industry and other sectors.
- A20. Development of mechanism for linkage and mobility of professionals among the academia, industry and research institutions.
- A21. Promotion of applied research through technology incubation and business development centres at educational and research institutions.

4.1.2 Technical and Vocational Education

39. Qualified technicians constitute the backbone of industrial production and services, needed for home and office appliances. The National skills strategy (2009-2013) document has correctly identified the contemporary trends for the demand of skilled labour shaped by (i) changes in existing technologies and emergence of new ones, (ii) emergence of globalized markets, (iii) increasing international competition, (iv) the necessity to attract Foreign Direct Investment, and (v) new modes of manufacturing, business models and marketing strategies.

40. Unfortunately, the Technical and Vocational education is the weakest link in the S&T manpower chain. According to UNESCO (2007) estimates Pakistan has 64 technicians per million population, while this figure for the technically advanced countries is in the range of 1500 to 2500. There are currently only 255,636[] enrolled students across 3,125[5] technical and vocational education and training institutes in Pakistan. Despite the establishment of TEVTA in Punjab and NAVTEC at the Centre, the national requirement of technically trained personnel cannot be adequately

met. The recent initiative by NAVTEC of crash programmes for vocational training is a step in the right direction and needs to be pursued more vigorously with increased outreach. The programmes of NAVTEC, TEVTA and similar agencies in other provinces need to be enhanced manifold in order to meet the national requirement as well as preparing trained manpower for employment abroad.

41. The successful example of the Pak-Swiss Training Centre of PCSIR at Karachi, which imparts training in precision mechanics and whose graduates are in high demand in the industrial sector was a good example of demand driven skill development. More centers for training in other trades such as forging, casting, metal working etc. also need to be established. If combined with a formal apprenticeship programme in the local industrial sector, this programme would go a long way towards solving the problem of non-availability of technically competent manpower. The PCSIR has now established similar Precision System Training Centres at Lahore, Peshawar & Quetta and a Cast Metal & Foundry Technology Centre at Daska which are in operation.

42. The lack of trained technical manpower for the operation and maintenance of major laboratory equipment, such as electron microscopes, spectrometers, gas chromatographs etc. is a major problem for universities and research establishments. This not only involves considerable expenditure on repair by the suppliers, but also causes disruption in the research work due to longer than necessary down time of the equipment. To address this issue, technical universities such as NUST, CIIT, GIK Institute and the Universities of Engineering and Technology should initiate specialized courses on the operation and maintenance of major laboratory equipment. The technicians produced by these universities, who would be able to operate and use the equipment for analytical work as well as maintain and repair them as and when necessary, would be in great demand in the research institutions and universities. PCSIR has established Repair Centres at

Karachi, Lahore, Peshawar & Islamabad. These Centres are equipped with necessary repair/diagnostic gadgets but unfortunately these are not fully utilized due to lack of interaction with universities. A programme started by PCST to provide funds for purchase of relatively less expensive spare parts by any laboratory in the country, turned out to be a useful exercise because in most cases very high value equipment was lying idle because of replacement of minor components.

43. The following observations made in the National Skills Strategy (2009-2013) are worth noting and relevant recommendations must be supported by the national ST&I system. "In Pakistan unfortunately, employers play a negligible role in influencing what is taught in TVET institutes. Because of weak institutional linkages with the industry, training is designed around skills and knowledge that are not necessarily relevant to the market".

"To provide the essential link between industry and government, it is proposed to establish sector-specific Industry Advisory Groups (IAG). Each IAG will be represented by members of large, medium and small industry, including all sub-industries that fall within the category, international employers, employees and civil society. Their primary responsibilities will be to carry out periodic sector surveys, identify skills needed in their sectors, indicate new and emerging areas and occupations and determine and update competency standards for workers".

"Staff training institutes will be strengthened in terms of equipment and variety and quality of courses. Where possible, staff training institutes will be linked with centres of excellence to ensure the provision of current, relevant training courses and master trainers".

4.1.3 In-service Training

44. Learning is a continuous process and the training or re-training of the employees is an essential activity in a dynamic organization. As noted in the National Skills Strategy document

“In the South Asian region the incidence of in-service training is very low. Amongst the four larger South Asian economies, Pakistan has the lowest incidence of in-service training i.e. at 8%. Major reasons for low in-service training in Pakistan are low demand for training, high turnover rate of workers and limited financial resources. Small and medium sized firms in particular, cannot afford to train their staff and both the firm and their workers, remain therefore, at a disadvantage”. [The National Skills Strategy, 2009-2013].

45. There are two complementary aspects for the success of upgrading the qualifications or skills of employees engaged by an establishment. First and foremost is the availability of opportunities. A progressive administration has to recognize that their employees would be more productive, if they are able to acquire new knowledge and technical know-how. The placement of desirous candidates, provision of required study training leave and any financial compensation that may be needed for undertaking the training would encourage the employees to enhance their qualifications.

The second requirement is that the employees should themselves be motivated for the advancement of their careers. The administration may use such incentives as pay hikes, promotions or award of honoraria for the efforts undertaken by the employees to upgrade their educational levels.

4.1.4 Non-formal Education and Training

46. The fragmentation of educational system in public / private and English- medium / Urdu-medium with a variety of standards ranging from open sky classes to posh class-rooms, is further aggravated by the presence of a “Madrassah” system providing exclusively religious education. At the critical mental development stage of below 10 years old students, the lack of understanding about the physical world based on laws of nature, which are not at all contradictory to the religious teachings, ultimately results in stunted growth of men-

tal faculties. The ensuing social problems are manifested in the form of extremism and lack of absorption in the mainstream job market. A science teaching package covering the basics of mathematics and natural sciences could be developed and integrated into Madrassah education system, apart from providing opportunities to learn a specific trade of economic worth.

47. In our society, technical training process of youngsters outside any educational framework also exists. The informal ‘Ustaad’ system, through which our mechanics, plumbers, welders, electricians etc. are trained in the private sector, needs to be recognized and institutionalized. The workshops, where the apprentices are currently learning their trade, could be recognized and registered with the Provincial Technical Boards as Authorized Training Establishments. The apprentices would also be registered with the Technical Boards and may be required to attend school one day per week. They would receive a certificate of proficiency in their trade after demonstrating their skill in a practical examination. The certification would enhance the chances of employment of the successful apprentices both in the local as well as the foreign labour markets.

48. The training programmes focusing on vocational training or enhancing skills through formal or informal mechanism would be enforced through a number of actions listed below:

Policy Actions:

- A22. Expansion of the network of technical training facilities.
- A23. Standardization of the training programmes to bring them at par with the internationally recognized qualifications.
- A24. Regulation of the Madrassah Education system and ‘Ustaad’ system of skill development.
- A25. The programmes under National Skill Strategy Policy to be integrated into S&T development system.

4.2 Service Conditions and Incentives for Scientific and Technical Manpower

49 In order to ensure that the investment made by the Government in establishing the S&T infrastructure and the training of the S&T manpower is used productively, it is necessary to provide a conducive environment and favorable working conditions to the scientists and technologists working in the research establishments. The introduction of the performance-based 'Tenure Track' salary system in the public sector universities has solved the problem of low emoluments of the faculty. Similarly, the Special Pay Scales system prevalent in the strategic research organizations and recently introduced in PARC has, to a large extent, reduced the sense of dissatisfaction among the scientists and technologists working in these organizations. However, the BPS salary system prevailing in the organizations of the Ministry of Science and Technology and other public sector research organizations has failed to attract and retain good quality S&T manpower in these organizations. In addition to the 'brain drain' to foreign countries, an internal brain drain is taking place, where the more capable scientists are being attracted to the universities and the strategic research organizations. Even fresh graduates, recruited after a lengthy selection procedure, either do not join or leave a few months after joining for a better-paying job in universities or the strategic R&D organizations. This state of affairs is highlighted by the fact that 33% of the posts in BPS-17 to BPS-22 in the organizations of the Ministry are vacant. To address this problem it is imperative that uniform, market-competitive pay scales be introduced in all S&T Organizations of the country.

50. The bulk of public-sector non-strategic R&D is being undertaken by various organizations under the control of Ministry of Science and Technology. Apart from low salaries and insufficient research facilities, there is also a weakness in their governance. Often, the nature of assignments and job description is not well-defined. The selection and promotion cri-

teria in most cases do not exist or not followed. Most of the organizations do not have their service rules, training procedures and medical reimbursement regulations. The R&D organizations under MoST need autonomy, good governance, uniform rules and regulations and strict efficiency criteria for career advancement of scientific workers. Another point of concern is the overburdening of these organizations with administrative and financial staff which creates hindrance rather than helping scientists in the matters that are the responsibility of the organizations, resulting in the wastage of scientists' precious time. The international norm for ancillary staff is typically of the order of 20%, whereas in MoST organizations it is usually of the order of 40-50%.

51. The heads of the organizations, besides being capable scientists, need to be good managers and administrators with the ability to guide and lead a team of researchers. They need to have the requisite vision and resourcefulness to steer the organization towards the achievement of its objectives. The emoluments of the heads of organizations, therefore, need to commensurate with the job requirements. As the current salary packages in BPS-21 or BPS-22 have failed to attract capable persons, the approval of salary packages in the MP scales or equivalent is a welcome step to attract right candidates. The Prime Minister has also approved the summary of Special Pay Scale to attract the energetic scientists and the case is now in Ministry of Finance for final action.

52. Apart from low salary, the lack of promotions and career advancement opportunities are major factors in the demoralization of the scientists working in the public sector research organizations. This is mainly due to the small size of the majority of the organizations, which severely limits the opportunities for career advancement. To address this issue, the organizations under the Ministry of Science and Technology should form a single cadre for their employees to facilitate the lateral movement of employees whose promotion might otherwise be blocked.

53. PCST report entitled “Proposed Service Structure and Technical Pay Scales for Organizations under the Ministry of Science and Technology” (March, 2006) recommends the adoption of a performance based service structure and pay scales similar to the SPS pay packages of the strategic R&D organizations. The proposed system, which is designed along the lines of the Tenure Track system of the public sector universities, permits, inter alia, accelerated promotions based on performance rather than seniority-cum-fitness, upgradation of posts etc. to avoid frustration of the younger scientists due to lack of promotion.

54. The reformation of employment system for S&T careers will be undertaken through following measures:

Policy Actions:

- A26. Creation of a single scientific and engineering cadre for all employees of MoST organizations on the basis of SPS pay scales.
- A27. Granting of autonomy to the S&T organizations under Ministry of Science and Technology and adoption of uniform rules, and regulations with performance based promotion criteria.

4.3 Motivational Measures

55. The achievement of excellence by an individual is greatly helped by a social milieu that bestows honours and awards for outstanding performance. In the absence of tangible rewards for extraordinary effort, there is often little motivation to achieve more than minimal satisfactory output. Motivational measures can take several forms, some of which may be the following:

- i. Highlighting the achievements of individual scientists/engineers to create an image of public respectability.
- ii. Bestowing civil awards and cash prizes for contributions that are deemed useful for the society.

- iii. Constituting special national awards for individuals and organizations that make important contributions towards the progress of science and technology.
- iv. Awards for specific groups such as best design of an indigenous product, innovative commercialization, invention of a significant economic worth, and so on.
- v. Boosting creativity by helping scientists with patent registration process and sharing the profits of commercialized products with the inventor.

56. The following actions would be taken to implement motivational measures and popularization of science:

Policy Actions:

- A28. Enlarging the scope of prizes and awards for individuals and organizations making important contributions towards S&T development and public awareness of their achievements.
- A29. Helping scientists in the process of patent registration and sharing profits of commercialized products.

4.4 Science Popularization

57. The public perception of science and how it affects the progress of a society is rather murky, due to negligible media coverage. Science and Technology are at best understood to be alien entities, penetrating our society through commercial ventures, benefiting multinational companies and in some cases even harming local cultural values.

This perception needs to change through realization that the science and technology is a product of imaginative thought process; it has no regional or ethnic bias. Anyone, anywhere, with a rational mind can probe the secrets of nature and find answers that can be used for human welfare. The students always like the subjects which they find interesting. Nothing can be more inspiring than the awareness of

the secrets of vast universe around us, or the evolution of a fantastic variety of life-forms, or the ability to control matter at atomic level. If a teacher is able to ignite the sense of wonder and curiosity in a student, rather than asking for memorizing arcane scientific theories without comprehending their essence, the purpose of making science popular will be amply fulfilled. The role of PSF in this respect has to be strengthened and its outreach enhanced significantly.

58. The minimal actions envisaged to strengthen science popularization schemes are:

Policy Actions:

- A30. Coverage of scientific lectures, meetings and reports on electronic and print media.
- A31. Strengthening PSF programmes and outreach for effective dissemination of information evoking public interest in science through, inter alia, science caravans and exhibitions.

Indigenous Technology Development



5. Indigenous Technology Development

59. Pakistan has traditionally supported a heavily protected industry and a large public sector with little competition as there was no pressure on the industry to become more efficient. Thus technology, which could have helped industry become more efficient, productive and competitive, could not play its proper role. Both India and China – China due to its isolation and India through deliberately high tariffs – kept their domestic markets closed to imports until their industrial sector had gained sufficient strength to compete in the world market. The originally low quality of their products has over the years been replaced by world-class quality through development of local technology combined with acquisition of foreign technology (reverse engineering). Their industrial products are now in a position to compete with those of other more advanced countries.

60. With the current globalization of trade and the WTO regime of low tariffs the industrial sector of Pakistan is increasingly coming under pressure to improve the quality of its products as well as the efficiency of its production processes to be competitive in the world market. Thus science and technology will become indispensable for the local industry for intelligent absorption of imported technology coupled with development of indigenous technology.

61. The R&D system of the country is currently oriented towards the supply side, with very little interaction with the industry, which is the ultimate user of the products or processes developed in the R&D organizations. There is negligible R&D activity in the industrial sector, in contrast to the industrialized countries where the industrial sector is a major contributor to the overall R&D effort of the country. There is, therefore, an urgent need to re-orient the public sector R&D organizations to demand-driven research in collaboration with the industry.

62. The ST&I Policy for indigenous technology development is, therefore, based on the following objectives:

- i. The R&D organizations should be oriented towards solving the problems of the industry regarding improvement of their products or processes. In this regard, Government-Industry partnership programmes should be launched where the researchers will provide technical assistance to the private firms/companies. Initially it will be necessary for the scientists to demonstrate that they are in a position to solve the problems of the industrialists within a reasonable time-frame and at a relatively low cost. Once this is established, the industrialists would be more willing to approach the R&D organizations and universities of the country rather than looking towards foreign countries. The Government can enhance the linkages between public R&D organizations and industries by directly supporting the industrial activities that are related to innovation, facilitating the commercialization of technologies, and sharing the human resources and technical facilities.
- ii. In order to encourage scientists to work on the problems of industry, a part of the income generated through research contracts with the industry may be given to the scientist/research group involved in the R&D effort. Similarly, the royalty accruing from the commercialization of a patent may be shared according to an approved ratio among the Government, the R&D organization and the scientist(s) who developed the patent.
- iii. Efforts should be made to attract the global R&D manpower in order to meet the immediate needs of the industry, while ensuring that Pakistani researchers are adequately trained, in their presence, to understand and meet the future needs of the country. Pakistani scientists / engineers serving in foreign countries should also be encouraged to return to their home country as

oped to facilitate the sharing of laboratory resources among R&D organizations and universities.

- their knowledge and international linkages may benefit the R&D sector of Pakistan.
- iv. The focus of research should be diverted towards a small number of strategic areas that yield the highest economic returns so as to develop and sustain research capabilities in the focused areas as well as to improve the competitiveness of the country's products in international trade. The reverse-engineering methods, where permissible, may be used wherever feasible.
 - v. The funding mechanisms for research should be improved by simplifying administrative and financial procedures in order to facilitate the research scientists/engineers in performing their duties.
 - vi. The R&D organizations of the country should have an enhanced financial autonomy that will result in a more focused approach, better utilization of human and financial resources, and improved decision making processes.
 - vii. There is a need of providing women with opportunities of higher learning so that they too could opt for research and development as a career. Similarly, scientific/research activities of young scientists/engineers need encouragement and support.
 - viii. The industry, especially the larger units may be motivated to set up their own R&D establishments. In India, 35% of the firms have their own R&D units while in Pakistan there are only a few. Appropriate incentives in the form of tax rebates on the amount spent on R&D activities by the industrial unit may be considered.
 - ix. The Government should invest in upgrading the S&T development infrastructure of the country by establishing new R&D organizations and improving the technical facilities of the existing ones. Currently, there is a non-uniform distribution of laboratory resources / equipment in the R&D organizations / universities of the country. Mechanisms should be developed to facilitate the sharing of laboratory resources among R&D organizations and universities.
 - x. The R&D organizations should focus on small and medium enterprises (SMEs) that generally do not have the resources to establish their own R&D facilities and provide them with technology information, R&D for product/process development, technical training, testing and analytical facilities etc. SMEs will be encouraged to employ S&T in general and ICTs in particular in order to improve their international business relationships. SMEs will also be encouraged to form clusters in order to improve the quality of their products/services and international competitiveness.
 - xi. Efforts need to be made to make optimum use of the opportunities offered by the WTO regime by utilizing the relatively lower labour costs, high traditional skills and a large pool of natural resources to develop products that can compete in the world market. R&D organizations like PC-SIR can help SMEs in developing products using the available natural resources.
 - xii. R&D organizations should establish Technology Incubation Centers (TICs) that provide affordable factory space as well as necessary support for business development, marketing, financing and legal services to facilitate new start-ups. The knowledge capital of the universities and research organizations should provide the requisite input in the development of new technologies and industrial products. HEC has already initiated a programme to encourage universities in setting up TICs.
 - xiii. Following the Chinese model, R&D organizations should be encouraged to set up semi-industrial scale pilot plants for manufacturing and marketing products developed by them. This will also motivate them to carry out economic feasibility studies before starting the research and development work.

- xiv. Develop a viable Metrology, Standards, Testing and Quality (MSTQ) system, to ensure the quality of the Pakistani goods in the world market.
 - xv. Exposure of international S&T developments should be provided to the researchers/scientists of the country. Pakistani R&D organizations should be encouraged to establish branches in foreign countries, and foreign R&D organizations should be allowed and encouraged to establish their branches in Pakistan. Efforts should be made to establish scientific information networks among local and international R&D organizations, focusing on joint R&D activities and co-development of technologies.
 - xvi. The researchers of the country should be encouraged to change fields and be facilitated to move freely between R&D organizations, universities and industries in order to introduce new ideas in the existing disciplines and to develop inter-disciplinary areas.
63. Based on each of the above-mentioned objectives, a number of actions would be required at the level of firms, R&D Institutions, Federal Government and Provincial Governments. The following measures will be taken in this regard:
- from abroad for addressing local industry issues.
 - iv. Technical support to SMEs for enhancing the quality of their products based on indigenous resources.
 - v. Establishment of technology incubation centers in R&D organizations.
 - vi. Prioritization for rapid development of selected industries with highest economic benefits.
 - vii. Analysis of reverse engineering potential and relevant issues, with recommendation of execution plans.
 - viii. Collaboration with foreign production sector to learn best practices.
 - ix. Improvement of MSTQ system.
 - x. Granting enhanced financial autonomy to R&D organizations.
 - xi. Motivating big industrial enterprises to set-up research wings.
 - xii. Establishment of new R&D organizations in multi-disciplinary areas.
 - xiii. Improving laboratory and field facilities of existing R&D organizations/universities and creation of a database of equipment for sharing the laboratory resources.

Policy Actions:

- A32. Constitution of a task force with a number of sub-committees to propose specific actions with the identification of agencies responsible for executing these actions in order to achieve the following results.
- i. Establishment of close linkages between industries and R&D institutions/universities.
 - ii. Incentives for scientists working on industry-related projects
 - iii. Induction of high-quality manpower

5.1 High Technology

64. In order to acquire high technology within a reasonable time-frame, it is necessary to promote technology transfer through Foreign Direct Investment (FDI) in the shape of joint ventures, production under license, technology-sharing agreements etc. There is also a need of establishing new and high technology industrial development zones in selected areas with adequate facilities and conditions. Improved mechanisms of information gathering, evaluation, and monitoring need to be established in order to assess the country's progress related to the development of new technologies. The

efforts of the Board of Investment for providing a liberalized environment for technology transfer needs to be intensified. Incentives such as tax holidays for setting up high-tech industrial units would go a long way to promote FDI in such industrial ventures.

65. All other things being equal, industrial FDI is attracted by the availability of a large stock of technically competent manpower. India, with its large stock of scientific and technical manpower, has succeeded in attracting a large quantum of FDI in the form of production units of multinationals, software houses and research laboratories of pharmaceutical companies etc. Pakistan needs to lay special emphasis on the training of its technical manpower at all levels. A largely literate and technically competent population is an asset, as skilled manpower is in great demand all over the world.

66. The strengthening of high technology sector will be achieved through following actions:

Policy Actions:

A33. Attracting FDI in advanced technology production through financial incentives and provision of physical infrastructure.

A34. Ensuring the availability of local manpower suitable for absorption in high tech companies.

5.2 Incentives for Development of Technology

67. To promote the indigenous development of technology, the government would also need to improve its incentive structures. In addition to taxation regimes and market-based instruments, preferential government procurement of locally produced goods can also be used to promote technological innovation and generate markets for new locally produced products. These measures would foster the creation of small and medium enterprises, which would play a leading role in the development of new opportunities and the use of technology. Special additional incentives might be

necessary to encourage new high-tech start-ups in fields such as biotechnology, information technology, nanotechnology etc. It needs, however, to be ensured that the incentives are not misused in acquiring obsolete or obsolescent technology. There is a need of initiating an awarding system in the country in which the individuals/organizations/companies will be rewarded for their outstanding contributions towards the advancement of S&T.

68. The following steps are essential for encouraging the development of appropriate local technologies:

Policy Action:

A35. Devising a public procurement policy that gives preference to indigenous products and processes.

5.3 Technology for Socio-economic Development

69. There is an urgent need for developing technologies that may facilitate the economic and social development of the country by addressing the basic needs of the people, and enhancing the competitiveness of country's industries in the international arena. The Japanese, Taiwanese and South Korean economic miracles are noteworthy examples. Due to its defense compulsions and despite relatively small industrial base, Pakistan has succeeded in developing technology for the production of defense equipment at great cost to the nation. It is now time for utilizing the store of expertise and technical know-how available in the strategic research organizations for the economic development of the country. For this purpose, a committee comprising the representatives of MoST, SPD and the industry should work out ways and means to transfer the know-how to the industrial sector. Implementation of this concept would give a large boost to the industrial sector and would contribute to increasing the share of manufactured goods in the export mix of the country.

70. Appropriate applications of the available

technology to address social development issues, such as provision of safe drinking water, or use of renewable energy resources for providing electricity to marginalized populations in far flung areas can greatly improve the quality of life of the people and contribute to the achievement of the Millennium Development Goals. Emphasis should be laid on conducting research in order to develop technologies for improving climate and environmental change forecasting capabilities, and predicting and handling emergencies such as earthquakes, floods etc. The R&D organizations should focus on developing simple technologies, which can be produced by the local industry, to address such problems. This would generate economic activity and employment in the local industrial sector and contribute to the economic development of the country. Moreover, in order to transfer the latest technologies/knowledge to the industry, technology parks should be created under universities and R&D organizations of the country so as to transform knowledge into products and services that result in socio-economic development.

71. To address the problem of rural unemployment (MDG: reduction of poverty) appropriate technologies and products based on locally available raw material need to be developed, and the village industries (small and medium) should be assisted and encouraged in developing collective brands. Through its SPARK programme, which used this concept, China succeeded not only in reducing rural unemployment, but also in establishing a rural industrial base, which currently produces goods whose export value is equal to the goods produced by its large industrial units. A similar programme may be initiated in Pakistan, in which the organizations of the Ministry of Science and Technology would play the leading role in developing technologies and products based on the locally available raw materials.

72. Appropriate technologies for directly benefitting common man will be developed and employed through the following steps:

Policy Actions:

- A36. Utilizing the know-how developed by a large pool of highly qualified manpower in strategic organizations for industrial applications.
- A37. Developing simple technologies for relieving the concerns of deprived sections of society, related to water, energy, housing, hygiene etc.
- A38. Taking steps to enhance the share of cottage industry in national economy.

5.4 Codification of Indigenous Knowledge

73. Pakistan's S&T policy has not taken account so far of the indigenous bases of knowledge and technology. The transfer of technology should be sensitive to the local knowledge base. In this regard, efforts should be made to create harmony between the technology being transferred and diffused and the stocks of indigenous knowledge and capabilities. South Africa's Department of Science and Technology has established the National Indigenous Knowledge Systems Office (NIKO) to promote indigenous knowledge in South Africa. One of the many steps taken towards this end was to design a degree in indigenous knowledge systems and the establishment of pilot centre at the University of Zululand for the purposes of researching, recording, codifying and spreading the indigenous knowledge. A similar initiative could prove very beneficial for Pakistan's economy as most of the business enterprises in Pakistan are micro, small and medium enterprises with a substantial indigenous knowledge component in their production techniques. Research and codification of indigenous knowledge may help introduce standards in this sector. The following would help achieve the required policy objectives:

Policy Action:

- A39. Establishment of a body under MoST for the codification of indigenous knowl-

edge and its effective use in production sector.

5.5 Management of Intellectual Property Rights Regime

74. As far as Science and Technology is concerned, the global system of Intellectual Property Rights (IPR) is designed to protect the scientific discoveries, technological innovations, and traditional knowledge. It ensures financial benefits for individual inventors and R&D organizations leading to motivation for creativity and increased interest for commercialization, thereby benefitting the society through enhanced industrial productivity.

75. The IPR regime in Pakistan has been strengthened after signing the agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs) under WTO. The Intellectual Property Organization (IPO) of Pakistan was established in 2005 and its legal position was defined through an Ordinance of the Government of Pakistan in 2007, as an autonomous organization under administrative control of Cabinet Division, responsible for implementing relevant legislations in Pakistan. The dissemination of information about patents and copyrights and provision of legal and administrative help to inventors is a well-known prerequisite for global competitiveness. Recognizing the important role that IPO (Pakistan) can play in this regard, it is envisaged to keep close liaison with this organization in order to achieve the overall objective of ST&I Policy.

Policy Action:

A40. Creating the position of a Liaison Officer in the Ministry of Science and Technology to coordinate the IPR related activities across all R&D organizations in close association with IPO, Pakistan.

5.6 Innovation Fund

76. Encouraging the inherent innovative capabilities of the people is a low cost and effective way of developing indigenous technology.

Many developing countries such as Malaysia, Argentina and India have reaped good benefits from this approach by establishing funds to finance such activities. The Government of Pakistan may also consider establishing an Innovation Fund, which would finance innovative capabilities of individuals, groups, organizations and firms in the private as well as the public sector. The size of the grant would be according to the categories defined while setting up the Fund and the Government would have a share (say 20%) in the income generated from any product or process developed under a grant from the Fund. Necessary arrangements will be made to implement the following policy actions:

Policy Action:

A41. Establishment of Innovation Fund to sponsor projects based on innovative approaches to enhance productivity.

5.7 Venture Capital and Equity Fund

77. Venture capital plays a critical role in the creation and development of small and medium enterprises, especially for new products and technologies. Besides providing the requisite capital, venture capitalists can help groom small and medium-size start-ups into multinational concerns. Therefore, appropriate fiscal incentives should be given to attract venture capital for creating new businesses and improve their sustainability. Public-private partnership can be enhanced through private equity funds. Public sector organizations under the oversight of the Ministry could be given sufficient autonomy to enter into financial arrangement contracts.

Policy Actions:

A42. Coordination with the financial institutions of the country to install Venture Capital schemes with public-private partnership.

A43. Devising rules concerning the availability of private equity funds to public sector organizations.

Technology Transfer and the Creation of Absorptive Capacity



6. Technology Transfer and the Creation of Absorptive Capacity

78. In the context of a developing country such as Pakistan, technology transfer takes place at two broad levels; international and national. International technology transfer entails the acquisition and transfer of technology from a more scientifically and technologically advanced country to a developing country. International technology transfer takes place through different channels. Capital goods imports and technological inputs serve to enhance the productivity when they are used in the production process. Another channel is Foreign Direct Investment (FDI) as multinational enterprises transfer technological information to their local subsidiaries. The third channel by which transfer of technology takes place is direct trade in knowledge licensing.

79. National technology transfer entails the further diffusion of technology from the early leading adopters to the whole sector of production and the identification and exploitation of promising indigenous research with a commercial potential. Seen from these two levels, technology transfer encompasses not only the process of innovation but also the diffusion of innovation represented as technology.

6.1 Absorptive Capacity for Technology Transfer

80. In order for both types of transfer of technology to take place successfully in Pakistan, there is a need to create absorptive capacity at the individual, firm and national levels. There is a need to develop the capacity of people, businesses and institutions to assimilate process and create new information. The process of acquiring, imitating, absorbing and diffusing technology is known as Absorptive Capacity. Enterprises in Pakistan can only be made innovative if funding is made available to building the absorptive capacity of business enterprises operating in the public and private sectors. Absorptive capacity is based on the accumulation of contextual knowledge and is path dependent. An organization's and firm's

absorptive capacity depends on how well it is exposed to using internal and external knowledge, its learning culture and capabilities and its organizational ability to exploit it within its subunits. Further, there is a need to ensure that maximum advantage is secured from the above three types of international technology transfer by incorporating the transfer and development of human and technological capabilities in technology transfer agreements. It should also be noted that technology transfer negotiation skills be imparted to personnel and institutions in public and private sectors who are involved in the process of negotiating the transfer of technology. Moreover, it should be remembered that technology transfer should not be limited to the transfer of physical stock of a particular technology but efforts should be made to acquire the set of disembodied skills and capabilities associated with a particular technology which prove vital in the process of further development of technology in the domestic setting.

6.2 Absorptive Capacity of the Firms

81. The domestic firms should be encouraged to become integrated into Global Production Networks (GPN) of the transnational corporations (TNCs). Special tax incentives should be reserved for those firms which become part of these GPNs. These incentives should not be cut and dried but need to change with the level of experience accumulated by firms as they progress from lower end of the value chain to the higher end. These incentives should be geared towards reducing the costs of doing business.

82. Moreover, local firms in chosen industries like software products, automotive parts etc. should become Original Equipment Manufacturers (OEMs) of the big transnational corporations to achieve economies of scale and facilitate the transfer of knowledge and information from the flagship corporation of the GPNs. Inter-firm collaboration should then be encouraged between local firms which operate as a part of GPNs and those firms which are yet

to become integrated into GPNs to promote the flow of knowledge, skills and technology from the higher to the lower end of the industrial spectrum.

6.3 University-Firm Collaboration and Scientific Mobility for Technology Transfer

83. Universities should be encouraged to collaborate with those industries in which the number of firms participating in the GPNs of multinational enterprises is the highest. This collaboration can become a very vital channel of international transfer of technology through these networks. The attraction of highly skilled Diaspora happens to be a crucial source of technology-related skills for institutional development, businesses and capital inflow. This mobility should be promoted so that the flow of highly skilled Pakistanis abroad is reversed. This mechanism contributed to the development of computer industry and software industry in Taiwan and India respectively. The highly skilled Pakistanis should be attracted

back to the country and then placed in key public sector research organizations collaborating with firms which have become a part of the GPNs.

84. The following actions will be taken to improve technology transfer mechanism in the country:

Policy Actions:

- A44. Provision of funding for increasing absorptive capacity of public and private production sector.
- A45. Tax incentives for firms that are able to integrate into Global Production Networks.
- A46. Directives for negotiating international trade agreements to ensure technology transfer.
- A47. Offering of incentives to achieve reverse brain drain.

International Cooperation



7. International Cooperation

7.1 Bilateral Cooperation

85. The Ministry of Science and Technology has signed agreements on S&T cooperation with more than 30 countries. However, with the exception of a few notable examples like China and USA, most of the agreements are dormant while there is sporadic activity in the case of other countries such as Turkey, Argentina etc. Intensive efforts are therefore necessary to have a lively and fruitful bilateral cooperation with other countries on the basis of mutual benefit. The guiding principle should be to strengthen the S&T system of the country and improve its capacity to contribute to the socio-economic development of the country. Besides, the cooperation with industrially advanced countries, where the main objective would be to build/improve technological capability, increased attention needs to be paid to S&T cooperation with countries that are at a similar stage or are at a lower stage of development as Pakistan; with countries at a similar level of development the objective should be sharing of experience for learning from the experiences of other countries and gain from the areas of their strength on a mutual basis while with countries at a lower level of technological development, S&T cooperation will be based on the expectation that by helping these countries in the technical fields benefits might accrue in other fields, such as trade. Emphasis is needed on the active collaboration related to S&T with the neighboring countries, whereas, there is a need of encouraging the country's R&D organizations, universities, scientists / engineers / technicians to establish cooperative links with their counter parts in the foreign countries.

86. It is also important that the terms of agreement between Pakistan and a partner country give sufficient liberty to relevant organizations in both countries for proposing joint projects. Direct interaction between the Principal Investigators in two organizations is necessary to chalk out an effective research programme

based on the available expertise and desired outcome of the project. The Ministry may designate a 'monitoring team', for periodic review of the status of each MoU and report to the Secretary in order to overcome any impediments. The team may also be entrusted to publicize bilateral agreements to a wide group of organizations and institutions as well as universities, to seek most appropriate research partners.

7.2 Multilateral Cooperation

87. Besides being a part of the UN system, Pakistan is a member of various international and regional agencies such as ECO, SAARC, D-8, COMSATS, OIC etc. that have multilateral cooperation activities in science and technology oriented towards socio-economic development. Pakistan should continue to participate in these multilateral programmes; in fact it should take the lead role wherever possible. Similarly, Pakistan should participate actively in 'big science' multilateral projects launched jointly by the technically advanced countries. Participation in the Large Hadron Collider programme of CERN, where contribution by Pakistan in the construction of the CMS detector components has enabled Pakistani scientists to carry out research work at the new facility. Similar participation in other international projects of this nature will increase the prestige of Pakistani scientists as well as that of the country in the international scientific community.

88. Pakistan has invested human and financial resources in establishing COMSATS which is an Inter-governmental Organization (IGO), with a mandate to promote South-South cooperation in Science and Technology. This unique opportunity of leadership role for Pakistan needs to be capitalized through a strong backing of Ministry of Science and Technology, Ministry of Finance and Ministry of Foreign Affairs. The COMSATS platform is a potent source of creating collaborative scientific ventures with other members of the organization spread over 3 continents.

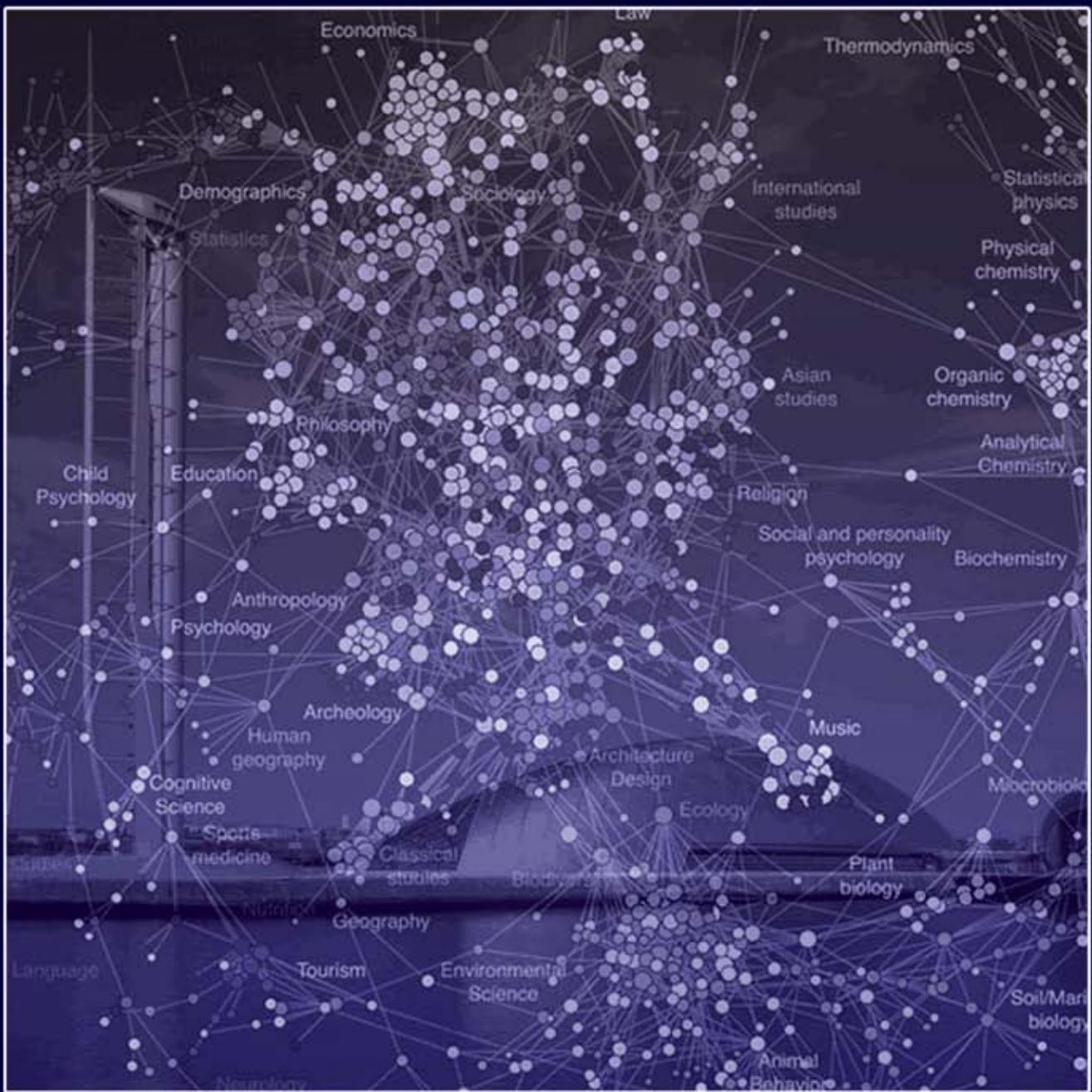
89. The importance of international S&T co-

operation as discussed above necessitates the following actions:

Policy Actions:

- A48. Designation of a 'monitoring team' for periodically reviewing progress on bilateral MoUs and dissemination of relevant information to research institutions and ministries.
- A49. Ensuring strong participation in multi-lateral scientific fora.
- A50. Capitalizing the scientific leadership role provided by Pakistan based IGOs.

Thrust Areas



8. Thrust Areas

8.1 Metrology, Standards, Testing and Quality (MSTQ)

90. Recognizing the need of a viable MSTQ system to meet the requirements of globalization of trade as well as ensuring the quality of goods in the local market, Pakistan has set up a nascent MSTQ system with three organizations, namely Pakistan Standards and Quality Control Authority (PSQCA), National Physical and Standards Laboratory (NPSL) and Pakistan National Accreditation Council (PNAC) as its components. The PNAC has achieved Mutual Recognition Arrangement (MRA) with International Laboratory Accreditation Cooperation (ILAC) and Asia Pacific Laboratory Accreditation Cooperation (APLAC).

91. A comprehensive document prepared by PNAC entitled, 'National Quality Policy and Action Plan - 2004', encompasses all quality related issues, such as; creation of quality environment, infrastructure development, quality control and quality assurance, technology up-gradation, consumer rights, awareness raising and human resource development. With an over-all budget layout of Rs.10Billion and well-defined time-based targets, the envisaged plan should have transformed the quality environment in the country. However, the implementation cell proposed under the Action Plan has partially achieved the objectives of the policy. With the termination of the project in December 2010, the implementation cell has become redundant. There is considerably more work that needs to be done under this programme, which can be either undertaken as uncompleted targets of the Action Plan - 2004 or through the approval of a Revised Action Plan for 2011-2015.

92. The creation of PSQCA in 1996 and the enactment of PSQCA act in 2000, was based on the realization that the standardization (development of standards and conformity assessment) plays a key role in the industrial progress and prosperity of a country. The participation of both public and private sectors in stand-

ardization activities is essential for enhancing Pakistan's competitiveness in international trade. Whereas, it is necessary to strengthen the national standardization infrastructure, a concerted effort to create awareness in R&D organizations/universities/general public about the role of standardization in economic growth would be required.

93. System needs to be revamped to remove remaining contradictions and weaknesses making it more effective. The steps envisaged for this purpose are:

Policy Actions:

- A51. Setting up NPSL as the National Metrology Organization as a separate entity, independent of PCSIR (subject to the enactment of a single cadre for employees of scientific organizations under MoST).
- A52. Strengthening PNAC and PSQCA in terms of manpower and infrastructure in order to enhance their roles of accreditation and standardization, respectively.
- A53. Restructuring PSQCA and redefining its functions to remove jurisdictional overlap with the functions of NPSL and PNAC through amendments in the PSQCA Act.
- A54. Increasing the number of mandatory standards manifold from its current figure of 85. These standards should also be enforced on imported goods to prevent the local market being flooded by sub-standard goods of foreign origin.
- A55. Harmonizing federal and provincial laws to ensure that the same standards are uniformly applicable throughout the country.
- A56. Involving the provincial setups in the enforcement of Pakistan Standards and strengthening them adequately for this purpose.
- A57. Increasing the number of ISO/IEC

17025 accredited laboratories and certification/inspection bodies in various sectors in the country to facilitate the availability of internationally acceptable accreditation to the exporters, and launching of new accreditation schemes on ISO/IEC 17024, ISO/IEC 17043, Product Certificate ISO/IEC Guide 65 and PS 4996:2010 for Halal Certificate.

8.2 Environment

94. Application of science and technology is essential for addressing the prevalent problems of environmental degradation. At present, we are in the habit of looking towards the technologically advanced nations for the solution to our environmental problems. However, appropriate application of simple technologies, either developed indigenously or adapted, can solve the majority of these problems. For example, the water filtration plant designed and developed by PCRWR for the removal of arsenic from water is a simple but effective solution. These plants, which can be easily manufactured locally, can be used for removing other types of water contamination using the appropriate medium. Standard water filtration units for community and individual families have to be developed and commercialized. Similarly, the hospital waste incinerator, developed by PCSIR and successfully commercialized through a private sector partner, is another example of local technology being used for solving local problems. The organizations of the Ministry of Science and Technology are in a position to develop technologies for solving other environmental problems. The Ministry of Climate Change and the Ministry of Science & Technology should team up to study and solve the various environmental problems. This should be combined with stricter and more effective enforcement of the national environmental laws, so that the environmental problems can be effectively dealt with. Support for Environment related projects at national level may be available through various international agencies such as Global Environment Facility (GEF). Other opportunities of international co-

operation and funding for transition to energy efficient technologies exist under Bali Action Plan for Technology Development, the Cancun Technology Mechanism, Clean Development Mechanism, Adaptation Fund etc.

95. The Ministry of Science and Technology will join hands with the Ministry of Climate Change to undertake actions listed below:

Policy Actions:

- A58. Development of cost effective sewage treatment plants.
- A59. Development of Industry-specific biotechnological waste-water treatment processes.
- A60. Power generation through incineration of solid waste.
- A61. Development of catalytic converters for retrofitting vehicles for minimizing the emission problems.
- A62. Assistance in meeting the objectives of Environment Policy - 2005, which inter alia, aim to:
 - i. Phase out sulfur from diesel and furnace oil.
 - ii. Establish cleaner production centers and promote cleaner production techniques and practices.
 - iii. Provide alternate sources of energy, like piped natural gas, Liquefied Petroleum Gas (LPG), solar energy and micro-hydel power stations, to the local inhabitants to reduce the pressure on natural forest, and to substitute firewood in the upland ecosystems.
 - iv. Promote the use of ozone friendly technologies; and phase out the use of ozone depleting substances in line with the provisions of the Montreal Protocol.
 - v. Promote recycling of agricultural products associated with livestock production and use of livestock sector as an

outlet for recycling of appropriate urban waste.

- vi. Introduce adequate animal waste management system in peri-urban dairy colonies.

8.3 Health and Pharmaceuticals

96. The pharmaceutical industry in Pakistan comprises national and multinational companies. Presently, there are about 400[] pharmaceutical manufacturing companies including 25[6] multinationals, which meet around 70%[4] of the country's requirement. The investment in the industry is around Rs.3 billion annually. The value of pharmaceutical sold in 2007 was US\$ 1.4 billion.

97. Whereas, Pakistan has attained a high degree of self-sufficiency in the formulation and packaging of finished pharmaceutical products, the manufacturing of basic ingredients is still limited and most of the active ingredients are imported. Research in the development of drugs is at a nascent stage. The Panjwani Centre for Drug Development established recently at HEJ Research Institute of Chemistry (University of Karachi) is the first institution dedicated for research in this field.

98. R&D in the sector of active ingredients (generic formula), quality herbal medicines, alternate medicines, biopharmaceuticals, biologicals and vaccines for both humans as well as animals is vital and needs to be strengthened. For this purpose international assistance in the capacity building of R&D organizations in this sector needs to be actively pursued. Upgrading the existing quality testing laboratories and setting up new ones in the vicinity of manufacturing clusters would cater for quality assurance of the drugs. Procedures for better linkages / collaboration between R&D institutions and the industry, particularly involving multinationals, need to be streamlined. Similarly, coordination between Ministry of Science and Technology and the federal and provincial health organizations / departments, in other areas requiring R&D for effective health deliv-

ery system and self-reliance in all Medicare aspects is envisaged under STI Policy.

99. An encouraging development in this connection is that PCSIR has signed an MoU with Chinese Academy of Sciences to help Medicinal Botanic Centre, PCSIR Peshawar to acquire the status of a WHO recognized Centre for Herbal Medicine. However, the technical training/ capacity building and exchange of expert visits component is suspended due to financial constraint / support by Federal Government. In view of the lower costs, proven effectiveness and social acceptability of local herbal medicines, this option for public health-care needs strong state patronage.

100. Research in the production of vaccines is of critical importance. As the EPI vaccines are being provided free of cost by UNICEF through a grant from GAVI, research in this field may not appear to be a priority area. However, to meet the growing requirement of vaccines for adults and to ensure vaccine security in case of denial due to a change in the geopolitical scenario, Pakistan should be in a position to produce its own vaccines. Besides the upgradation of the vaccine production facility at the National Institute of Health to meet the WHO GMP standards, setting up of other GMP-compliant manufacturing facilities in the public as well as the private sector should be encouraged. The production of animal and poultry vaccines in the public sector, e.g. at the Veterinary Research Institute, Lahore and Poultry Research Centre Karachi needs to be increased manifold for meeting the total requirements of the country.

101. The steps to be taken for improving indigenous capacity in health and pharmaceutical sector are listed below:

Policy Actions:

- A63. Development of R&D capacity for producing active drug components and upgradation of drug quality testing laboratories.

- A64. Necessary steps for PCSIR, Peshawar to be WHO recognized Herbal Medicine Centre.
- A65. Establishment of new facilities for vaccines production and manufacturing of medical instrumentation and diagnostic equipment for local needs as well as export purposes.

8.4 Energy

102. In order to overcome the current energy crisis and to ensure energy security of the country on a sustainable basis, the emergency measures being undertaken at present need to be supplemented by vigorous R&D efforts, especially for reducing the dependence on imported oil and increasing the share of other sources such as nuclear, renewable and coal in the energy mix of the country. The vast deposits of lignite coal (175 Bt) in the Tharparker District of Sindh province spread over an area of more than 9000 square kilometers are the most suitable for Coal Gasification. With a combined system of gas and steam turbines, the efficiency of electricity production from coal gas can be as high as 60%. Apart from the production of cheap electricity (< Rs. 6 per unit as compared Rs. 9-12 per unit with furnace oil plant), there are a number of by-products of high economic value that can be extracted by chemical-reprocessing of the synthetic gas, such as fertilizers, plastics, diesel etc. While efforts are underway to utilize this enormous energy source, all S&T organizations with relevant experience have an obligation to undertake R&D for the most effective, environment friendly and economical utilization of Thar coal. The presence of brackish underground water covering coal deposits is a challenge as well as an opportunity. If cheap energy is available on-site, the water treatment plants can generate enough water to convert the desert into arable land.

103. The Policy for Development of Renewable Energy for Power Generation (2006) formulated by Alternate Energy Development Board of Pakistan envisages increase in the deployment of renewable energy technologies (RETs) in Pa-

kistan so that RE (solar, wind, biomass, tidal, geothermal etc.) provides a minimum of 9,700 MW by 2030 and helps ensure universal access to electricity in all regions of the country. According to the Policy document this objective would be achieved through a number of measures including the facilitation of the establishment of domestic RETs manufacturing base. Facilities and manpower available in PCRET can be utilized to achieve the stated target.

104. Other sources of energy that need further efforts to enhance their share of energy-mix are hydel and Nuclear power. The Ministry of Water and Power and Pakistan Atomic Energy Commission, respectively, are the agencies responsible for development in this sector. The total hydropower potential in the country is close to 57,000 MW whereas, the current installed capacity is only 6464 MW. Apart from the on-going projects of 1505 MW [], other feasible projects can generate upto 24000 MW. The PAEC envisages to produce 8800 MW by year 2030 through nuclear power reactors. However, the coordination of the overall energy production efforts in the country and creating synergies among various R&D fora are necessary for achieving self-sufficiency in this sector.

105. Considering the variety of stake-holders and broad spectrum of technologies involved in energy production, the S&T policy objective would be achieved through following measures:

Policy Actions:

- A66. Harmonizing the efforts made in the energy sector by different Ministries, departments and research centres by creating an 'Energy Council' with heads of relevant organizations. The Council will be entrusted to advise on priority areas for R&D and management of resources and to fill the gaps.
- A67. Acquisition of technology for building nuclear power reactors through R&D as well as transfer of technology agreements.

- A68. Constituting R&D task force for developing processes to convert Coal and Coal gas for environment-friendly energy productions and their conversion to economically useful products.
- A69. Development of pilot projects and their large-scale dissemination based on existing technologies such as solar water heaters, biogas plants, photovoltaic etc.
- A70. Announcement of incentives (e.g. tax holiday) to the private sector for the manufacturing of renewable energy products, components and systems, such as solar thermal power system components, wind energy technology components, biogas plants etc.
- A71. Creation of a 'Renewable Energy Fund' for research into the development of new RE technologies such as hydrogen fuel cell, Fresnel mirrors and low-cost/high-efficiency photovoltaic panels.
- A72. Ensure utilization of alternative energy sources and get adequate allocation for actualization of provincial projects/plans.

8.5 Biotechnology and Genetic Engineering

106. As a cross cutting field, biotechnology has applications in agriculture, medicine, energy, environment and industry. In Pakistan there are 26 institutions engaged in education and research in biotechnology and genetic engineering. However, limited resources, inadequate stock of trained manpower and lack of proper coordination among the institutions are some of the reasons why this sector has not been developed to its full potential.

107. A National Commission on Biotechnology was established in 2001 to streamline and promote research in this vital sector and during the last few years over Rs. one billion have been invested on R&D in this priority area through various projects approved by the Ministry of Science and Technology and the Higher Edu-

cation Commission (HEC). A variety of Bt Cotton developed by the Centre of Excellence in Molecular Biology (CEMB) has been approved by the Punjab Seed Council and is ready for plantation in the field.

108. To promote the R&D as well as commercial aspects of biotechnology in the country, increased government support is required for promulgation of biotechnology legislation, defining standards in accordance with international practices and in establishing technology incubators and biotech parks in public sector in major cities of Pakistan. International cooperation for capacity building in this area through joint research projects needs to be actively pursued.

109. The Ministry of Science and Technology may assist in the adoption and implementation of "National Biotechnology and Genetic Engineering Policy and Action Plan", proposed by the defunct National Commission on Biotechnology, which has not been approved so far.

110. Considering that biotechnology has the greatest potential of transforming the way the human communities will lead their lives in future, it is considered necessary to adopt following steps:

Policy Actions:

- A73. Re-establishment of 'National Commission on Biotechnology' and charging it with the task of coordinating nationwide research programmes in different areas where biotechnology can be applied.
- A74. Reviewing the draft of 'National Biotechnology and Genetic Engineering Policy and Action Plan' and implementing it with the support of relevant organizations.
- A75. Enacting biotechnology related legislations.
- A76. Establishment of biotechnology incubation centers.

8.6 Agriculture and Livestock

111. Despite contributing 20-25% of the GDP and being the mainstay of our economy, it has not been possible for one reason or the other, to exploit the livestock and agricultural sector to its full potential. Significantly lower average yields of crops, persistent decrease in the quantity as well as the quality of water available for irrigation, high cost of fertilizers, limited availability of quality certified seeds, weak pest management and large post harvest losses are only some of the factors limiting the growth of this critical sector. Today about 30-35 million[] people in rural areas are engaged in raising livestock and about a third of their income is generated from selling livestock products. Still Pakistan is spending a significant amount of foreign exchange on the import of food grains, meat and dairy products. Also, WTO agreements (especially, Agreement on Agricultural, Trade-Related Aspects of Intellectual Property Rights (TRIPs), and Sanitary and Phyto-sanitary Measures) pose serious challenges to this sector. Pakistan has great potential to export Halal Food all over the world provided that there is a strong certification and quality control system within the country to address the issues related to Sanitary and Phytosanitary (SPS) and Technical Barriers to Trade (TBT) under WTO obligations.

112. The initiatives of PARC and provincial networks of R&D organizations in genetic modification leading to higher yields and pest resistance in major crops and improvement of livestock traits (disease/heat resistance, high meat / milk yield), establishment of seed testing and production facilities and R&D efforts to minimize post-harvest losses need to be intensified. Special measures are required to address the post harvesting losses of fruits and grains, increasing the storage capacity and improving packing & transportation facilities to enhance the shelf-life and quality of food. The recent concrete measures by the Ministry of National Food Security and Research, through federal and provincial R&D organizations, for the development of the livestock sector, like ca-

capacity building of institutions involved in animal breeding, up-gradation of animal health laboratories and establishment of Livestock and Dairy Development Board with greater participation of private sector are steps in the right direction.

113. To ensure food security for the country on a sustainable basis, some of the research areas requiring increased attention are the use of genetic engineering for a quantum jump in crop yields, development of crop varieties suitable for arid and semi-arid regions, development of quality, disease-free seeds and identification of new sources of resistance against major pests of various crops. The use of remote sensing technology for crop surveys, pest surveillance and monitoring of the irrigation system is required to obtain advance warning of any impending crisis. Development of on-site food processing technologies would help in reducing post harvest losses. Research efforts are also required in breeding disease resistant poultry birds and development of vaccines for protection against diseases like avian flu etc. To sustain our poultry industry, the farming needs to be done on more scientific basis using modern production/protection technologies. Similar efforts are required in case of fisheries. Inland fish farming including farming in brackish water also needs to be developed on a priority basis.

114. Better coordination between Federal and Provincial agricultural R&D establishments is necessary in order to avoid duplication and wastage of energy and resources. Modalities for a more efficient and fruitful interaction between end users and R&D institutions have to be worked out. Recent climatic changes as a result of global warming are already having an effect on the crop cycles. This interrelated shifting of weather pattern and crop cycles needs careful consideration and analysis for dealing with the problem in a timely manner.

115. The critical dependence of Pakistan's economy on agricultural sector necessitates a policy geared towards self-sufficiency in all types of food commodities and edible oils, as well as enhanced exports of Pakistani produce.

Some essential steps required in this respect are:

Policy Actions:

- A77. Development of genetic modification expertise for producing high yield/ pest resistant crops.
- A78. Using new technologies such as remote sensing, laser land-leveling, bio-fertilizers and solar tube-wells for enhancement of efficiency in the sector of farm produce.
- A79. Producing, preserving and processing fruits and vegetables that satisfy food-chain requirements of the international market.
- A80. Establishing facilities for producing quality controlled Halal food for Muslim consumers in different parts of the world.
- A81. Supporting schemes for modern techniques in poultry, livestock and fish farming.

8.7 Water

116. Pakistan possesses world's largest irrigation system commonly called the Indus Basin Irrigation system. Water Resources of Pakistan consists mainly of rainfall, rivers, glaciers, groundwater etc. Pakistan's estimated current per capita water availability of around 1,066 M3 places it in the "high water stress" category. Due to increased demand of water for irrigation, industry and public use, the per capita water availability will be further reduced to 858 M3 by 2025.

117. Pakistan is facing a serious water problem today and the gap between demand and supply seems to be widening. Currently, over 35 percent of Pakistan's population does not have access to safe drinking water. The quality of drinking water supply is poor, with bacterial contamination, arsenic, fluoride and nitrate being the factors of major concern. The vast ma-

jority of the population does not have access to safe drinking water, due to which incidence of water-borne diseases is increasing rapidly. High population growth rate, urbanization, industrialization and new environmental constraints are aggravating the problem. It has been estimated that water, sanitation and hygiene related diseases cost Pakistan's economy about Rs.112 billion per year, in terms of health costs and lost earning.

118. Appropriate legislation is required to ensure compliance with the Pakistan Standards for drinking water by individuals and institutions. Serious research efforts to develop and test simple technologies for sustainable availability of safe drinking water are required on an urgent basis. The project for establishing water treatment plants in all union councils is still under implementation and needs to be expedited on a fast track basis. Development of inexpensive desalination techniques for converting the brackish groundwater into safe drinking water needs to be pursued urgently. Already developed inexpensive desalination technologies for converting brackish groundwater into safe drinking water need to be promoted and transferred to end users.

119. The sustainability of agriculture depends on the judicious use of water and management of water resources. Serious research efforts are required for the development of water conservation technologies, taking the local climatic conditions, soil properties, social norms and economic situation into account. It is worth mentioning that a substantial amount of water (31.48 MAF) escapes into the Arabian Sea. Current canal water distribution is wasteful as 60-65% of the water available at the canal head is lost due to seepage, evaporation-transpiration, theft, poor operation and maintenance etc, before it reaches root-zone in the intended farmers' field, resulting in low crop-productivity per unit of water. In this regard, NARC, PCRWR and other Provincial irrigation departments have developed the techniques like trickle, drip irrigation etc, by which water can be conserved. These techniques need to be promoted

for utilization by farmers. In Arid zones, our agriculture is totally reliant on rainwater. There is an urgent need to develop and promote rain-water harvesting techniques. To minimize the water loss in canals, NESPAK have concreted the canals of Punjab. Other provinces should follow suit. Promulgation of the “Water Conservation Act” and relevant standards to foster water conservation has to be pursued vigorously. R&D organizations need to undertake concerted efforts for research in inter-related areas of water resource management; development and management of groundwater; assessment and mitigation of desertification; impact of climate change on water availability; saline agriculture and disposal and re-use of saline water. There is also an urgent need to develop a modus operandi for transferring the results of R&D to the end users.

120. The National Water Policy has been approved by the Cabinet in September 2009. The policy is aimed at achieving, inter alia, the target “to provide safe drinking water to 93% of the population by 2015 thereby raising the current coverage by almost 30% for the existing population and ensuring that the additional population is also provided access”. The Ministry of Science and Technology should assist all relevant agencies for the achievement of these goals. Pakistan Environmental Protection Council (PEPC) headed by Prime Minister of Pakistan has recently approved National Drinking Water Standards. EPAs have been mandated for the enforcement of standards; however, EPAs do not have capacity/capability to address the issue of drinking water contamination all over the country. Not only the drinking water but surface water i.e. rivers, dams and canals are also badly contaminated due to municipal, agricultural & industrial solid / liquid waste. Majority of industries and municipalities do not have treatment facilities. One of the issues is local manufacturing/ installation of treatment plants to cut down the high price of imported plants. Cooperation among different departments at national, provincial and district level is required to achieve the desired goals.

121. In light of the existing precarious nature of water resources and critical dependence of the national economy on sustainable availability of water for domestic, agricultural and commercial use, the actions to be put in place are:

Policy Actions:

- A82. Providing help and support for the implementation of ‘National Water Policy – 2009’ and ‘National Drinking Water Standards’.
- A83. Completion of projects for establishing water treatment plants in all union councils.
- 84. Implementation of water conservation technologies and assistance in the promulgation of the Water Conservation Act.
- A85. Development of inexpensive techniques for water desalination and purification for domestic use, and treatment of waste water.

8.8 Minerals

122. Although, Pakistan is generally regarded as being rich in mineral resources, the development of these resources has been limited to some quarries producing industrial minerals of limestone, rock salt, marble, gypsum and a modest amount of coal for power generation. There has been very limited exploration using modern management, adequate capital and proper technical know how, with the result that mineral exploitation contributes less than 1% of GDP at present.

123. In order to fully harness the available potential, the implementation of the National Minerals Policy that was formulated in 1995 with the objective to facilitate private investment in mineral development, needs to be seriously pursued. There is a need to work out ways and means for the involvement of multinationals and removal of all barriers in this regard. While encouraging foreign capital and technology, it is also necessary to ensure the national interest through well-considered con-

tract negotiations. The export of unprocessed ore is to be avoided at all costs, since the by-products, such as gold in Cu ore, and other precious rare-earths are lost without any accounting.

124. Long-term efforts are required for mapping and interpreting the geology of the related areas; setting standards for and undertaking contracted aeromagnetic, geo-chemical and airborne radiometric surveys; conducting national mapping programmes of the earth's gravitational and magnetic fields. Expertise on the nature and origin of national mineral deposits including the development of innovative exploration guidelines, techniques and technologies and providing expert knowledge and information on natural hazards such as earthquakes, volcanoes and magnetic storms in related areas also needs to be developed. Serious R&D efforts are required to develop cost efficient and clean coal technologies for harnessing the huge reserves of coal (175 BT in Thar only) for use in the power sector.

125. In support of relevant national and provincial departments and agencies responsible for harnessing Pakistani minerals including coal, ore and gas, the following actions would be carried out:

Policy Actions:

- A86. Provision of support for the implementation of National Minerals Policy 1995.
- A87. Undertaking R&D work for utilizing the full potential of coal reserves.
- A88. Development of technologies for processing different indigenous ores to extract products of high commercial value.

8.9 Ocean Resources

126. Pakistan, with a relatively long coastline of about 1000 km, has an Exclusive Economic Zone (EEZ) of 240,000 sq. km. in which it has exclusive control over all the living and non-living resources of the ocean. Another more

than 50,000 sq. km. of seabed – with the non-living resources beneath it – is expected to become available with the successful processing of the case for the establishment of the outer limits of the continental shelf under the UN Convention on the Law of the Sea (UNCLOS, 1982). In order to utilize the resources of the sea in a sustainable manner, it is essential to map the available resources through oceanographic, bathymetric seafloor classification (habitat mapping) and high resolution seismic surveys. Programmes for the mapping of bio-resources as well as the geo-resources need to be initiated as soon as possible to take stock of these resources. For these purposes two oceanographic research vessels – one for working in coastal areas and the other for surveys in deep waters – are required. Pakistan also needs to develop capacity in the areas of mining of the seabed, for utilizing the minerals, e.g. manganese nodules, lying on the seabed. The Antarctic programme, which has been dormant for some time also needs to be re-initiated. Capacity building of the National Institute of Oceanography in the areas of mapping of tidal energy potential, bathymetry, high resolution marine acoustics, integrated coastal zone management, aquaculture, monitoring of marine pollution etc. is necessary for it to carry out its mandate effectively and efficiently.

127. Marine Scientific Research in the Arabian Sea has found evidence of the presence of large quantity of gas hydrates in the offshore areas of Makran Coast. Target oriented exploration activities are required to be conducted to quantify and map the expected potential of this huge source of natural methane gas as well as Oil and Gas resources in maritime areas of Pakistan with close cooperation and support of Private Sector including Oil & Gas Industry. In general, the exploration and exploitation of Pakistan maritime areas has to be pursued more vigorously to meet the future challenges of energy demand.

128. Pakistan's long coastline is the source of income to thousands of fishermen. Pakistan has a well established fisheries industry that

is suffering due to lack of financial resources. This situation needs to be remedied through coordinated efforts.

129. In order to fully utilize ocean resources, some of the required actions are:

Policy Actions:

- A89. Mapping of oceanic resources in the maritime Exclusive Economic Zone as well as under seabed for assessing the potential of their utilization.
- A90. Exploitation of tidal energy potential and sea-based minerals such as manganese nodules and gas hydrates.
- A91. Development of sea-based aquaculture and fishery industry.

8.10 Electronics

130. As the world's largest industrial sector and most lucrative consumer market with an annual turnover of US\$ 1.5 trillion (in year 2004) [], electronics needs special attention. Pakistan has not been able to establish a viable industrial base in this sector, as the share of electronics in the country's manufacturing sector is only 3%. Efforts are therefore needed, for developing this sector for meeting the country's requirement in industrial, defence and consumer electronics. Development of automation controllers for the automation of the local industry, CNC controllers and PC-based controllers for CNC machines etc. would help boost industrial production as well as improving the quality of the products. Setting up of Electronics Facilitation Centres with modern electronics design and quality assurance laboratories, expert services for design and prototyping as well as high-tech SMT machines for assembly of printed circuit boards (PCBs) would facilitate the industry in the production of internationally competitive products in terms of price and quality. Such facilitation centres should be set up in the federal and the provincial capitals to support the local electronics industry through 'economy of scale', supply of parts, sub-assemblies and kits

at competitive prices compared to those being imported. The National Institute of Electronics (NIE) could be developed into the Electronics Facilitation Centre at Islamabad.

131. The requisite actions based on the policy of utilizing full potential of modern electronics industry are as follows:

Policy Actions:

- A92. Launching of specific programmes for the automation of local industry.
- A93. Setting-up Electronics Facilitation Centres for providing advice, training and services to support production of electronics goods and electronics-based equipment.

8.11 Information and Communication Technologies (ICTs)

132. ICTs have emerged as the major factor of growth and development in modern world. The ICT capabilities of a country can greatly affect its capacity of innovation and global competitiveness leading to improvement of socio-economic development prospects.

133. In Pakistan, ICT sector has seen a prominent growth during the last two decades. Pakistani ICT and Information Technology Enabled Service (ITES) companies have shown growth rate of 30-40%. Some of these companies have been represented at various international events. Pakistan has jumped 11 places, from 98 to 87, according to the rankings of the Global Information Technology Report 2009-2010 released by the World Economic Forum (WEF).

134. Similarly the tele-density has increased from 4.3% in 2002-2003 to 65.4% in 2010, with 108.9 million phones including; 102.7 million cellular subscribers of 5 GSM Operators (Mobilink, Zong, Ufone, Warid, Telenor), 3.4 million fixed lines, 2.7 million Wireless Local Loop and 1.0 million broadband subscribers. Currently, the IT and Telecom Sector is one of the major source of Foreign Direct Investment in Pakistan. The ICT industry size in the country

is estimated to be USD 2.8 billion[8] and total IT/ITES exports have been valued at USD 1.4 billion[].

135. The key institutions involved in promotion and facilitation of IT and Telecom Sector in the country include different organizations and user-groups. However, on an institutionalized basis, the following organizations are responsible for ICT development:

- i. The Ministry of Information Technology and Telecommunications (MoITT) is responsible for developing policies for IT and telecommunications.
- ii. National Telecommunication Corporation (NTC) caters for government communications and acts as an alternative support for the operators entering the market.
- iii. The Universal Service Fund (USF), Ministry of Information Technology and Telecommunications is responsible for telecom development in the under-developed areas via subsidies from a contributed Fund.
- iv. The Pakistan Software Export Board (PSEB) oversees IT growth and export.
- v. National ICT R&D Fund, Information Technology and Telecommunications supports research relevant to ICTs.

136. In addition, there are several active trade bodies having strong interest in the development of ICTs. These include:

- i. Pakistan Software Houses Association (PASHA)
- ii. Internet Service Providers Association of Pakistan (ISPAK)
- iii. Computer Society of Pakistan (CSP)
- iv. Federation of Pakistan Chambers of Commerce and Industry (FPCCI)

137. It is evident that ICTs are playing a leading role in accelerating economic growth and promoting sustainable development. Pakistan has made a significant leap and will continue to do

so if forward-looking initiatives are taken well in time. Some of the proposed measures are:

Policy Actions:

- A94. Support for the implementation of the National IT Policy and Action Plan.
- A95. Establishment of public ICT Industrial Parks.

(There are number of existing IT / ICTs parks but the proposed ICT industrial parks will consist of many national level sub-parks and technical support bases, including; microelectronics industry, software industry export base, software industry base, semiconductor lighting (light emitting diode - LED) base, information security base, IC design industry base, electronic information industry base, IC design park, multimedia industry park, multimedia valley, digital media industry park, international outsourcing park, opto-electronics industrial park, panel display industry base & support software parks).

- A96. Deploying ICT across sectors to improve the sectoral growth, e.g. SMEs to be encouraged to use ICTs for improvement of their competitiveness.
- A97. Supporting e-commerce and e-governance applications
(Many countries in Asia are taking advantage of e-commerce through opening of economies, which is essential for promoting competition and diffusion of internet technologies).
- A98. Encouraging entrepreneurial activities such as offshore low-cost Business Processing Centres.
- A99. Promoting open source software.

(The establishment of a central body is recommended to develop and monitor a standard, free open source software that can be implemented in all public offic-

es and educational institutes. This will help in saving handsome amount that is being given against purchase of annual licenses. In this regard, Indonesia's model can be adopted. Indonesia has more than 90% of Govt. offices on locally maintained open source software).

A100. Sharing of ICTs resources to meet large volume computing

(There is a need to introduce and support shared ICT services (like web platforms against security threats, information portals, development of street views) and provide large volume computing services (by installing super computers for public use by large entrepreneurs / multinationals). Service can be provided on rental basis to ensure sustainability of the service).

A101. Offering ICT-related financial incentives (tax holidays / introduction of special tax rates for software exporters etc.).

A102. Establishment of the citizen-centered e-state and development of the framework for customer-friendly business-to-consumer and business-to-business services.

A103. Making further improvements in liberalization of telecommunications market, well-functioning regulatory environment and high-level national education in ICTs.

8.12 Space Technology

138. The use of outer space has enormously increased since the launch of sputnik in 1957. Some of the most critical communication systems such as GPS, air traffic control, internet, banking etc., all depend on the use of satellites. The classical use of imagery from outer space has been a source of intelligence as well as environmental assessment. The natural resources management and environment monitoring can be done most effectively using remote sensing data on the agricultural land use, hydrology,

and mineralogy. Satellite-aided search and rescue operations on land, sea and air are now a common occurrence. Similarly, the monitoring of climate changes with meteorological satellites can help prevent losses due to natural disasters. Important applications in disease control and health services can be delivered through space based satellites.

139. Currently, there are about 3000 satellites of various types orbiting the earth, belonging to different space-faring nations, the most dominant of which is the United States of America. Realizing the importance of space capabilities for economic and defense advantage, India is spending about US\$ 650M per year on its "Indian Space Research Organization", employing a work force of over 16000 personnel. Pakistan's efforts in this area have not been impressive. In spite of the fact that SUPARCO was established as early as 1961, only two indigenous satellites BADAR - 1 and BADAR -2 have been launched. Earlier Pakistan had one leased satellite in geostationary orbit to meet its telecommunication requirements. In 2011, this satellite was replaced by PAKSAT1R. Pakistan has to enhance its space technology significantly in order to preserve its security, and to meet environmental, communications and commercial requirements. The establishment of an Institute of Space Technology (IST) in 2002 was a major step forward. The funding of both SUPARCO and IST must be enhanced to preserve critical national interests in upper space.

140. In recognition of the crucial role that space technology can play in the defense, agriculture, communications, and disaster relief, the following actions are envisaged:

Policy Actions:

A104. Launching of a coordinated effort by all relevant R&D and higher education institutions to develop indigenous satellites and expertise pertaining to space technology.

A105. Setting-up institutional linkages of MoST with SUPARCO and IST.

8.13 Materials Science

141. Materials science plays a significant role in the economic progress of a country and contributes directly towards the growth of the industrial sector, particularly; ceramics, plastics, metallurgy, aerospace, telecommunications, transportation, electronics, micro and optoelectronics, energy, healthcare, computing, consumer goods, and construction. The relevance of materials science with modern technological developments needs to be underscored. It is necessary to provide highly trained manpower in this field in order to meet the present as well as future needs of the country.

142. The world's focus of research is currently on engineering smart materials. These include piezoelectric, electrostrictive, magnetostrictive, electrochromic and rheological materials, hydrogels, shape memory alloys, sensors etc. Composites are another type of materials, which are made from two or more constituent materials having significantly different physical or chemical properties. These are finding popularity in high-performance products due to their lightness and strength, such as aerospace components, cars, bicycles etc. Graphene, which is one of the strongest materials ever tested with a breaking strength 200 times greater than steel for equal thickness, is also under spotlight and is finding applications in the form of single molecule gas detection, graphene nanoribbons, graphene transistors etc.

143. Modern materials science has become a multidisciplinary area and hence requires strong linkages among physicists, chemists, biologists, engineers, mathematicians and computer scientists. Greater emphasis is needed on developing fundamental understanding of materials science (tailoring materials in order to acquire the desired properties and to meet the requirements of specific applications), its applications and product development, as well as utilization of advance analytical, synthesis and processing techniques, and computer modeling. Like China (which is controlling 97 percent of the world's rare earth element mar-

ket), Pakistan needs to develop a strong base of research in rare earth elements/alloys, which are considered as critical components of the high technology products. Some of the emerging applications of smart materials are in textiles, coatings, electronics, sensors etc.

144. There is a need of conducting research on all classes of materials including hard and soft materials, metals, inter-metallics, organic and inorganic semiconductors, polymers, composite materials, biomedical materials, and vitreous materials. Priority should be given to materials synthesis for prevailing ambient conditions of Pakistan and characterization techniques in order to understand and define the properties of materials. It is necessary that the latest equipment and research facilities are made available to the researchers.

145. Although, there are various universities in Pakistan offering Masters and PhD level courses in the field of materials science, as well as various laboratories in the same field are operational, there is a need of establishing a number of research institutes for materials science at the national level, each specializing in one or multi-dimensional areas. These centers must act as an interface between the academic institutions and the industry. Establishment of more departments in universities/R&D institutions/laboratories in Pakistan dealing with the same field is also needed in order to achieve the desired level of expertise/competence.

146. The existing gap in developing a strong base of materials science research would be plugged with the following actions:

Policy Action:

A106. Establishment of a National Materials Science Research Institute with a centralized supercomputing facility for computational materials science or condensed matter physics.

8.14 Nanoscience and Nanotechnology

147. Nanoscience deals with the study of mat-

ter at nanoscale, i.e., one billionth of a meter, and nanotechnology is the ability to fabricate devices at this scale for applications. Matter having size of a few nanometers has large surface to volume ratio, thus the surface properties dominate over the bulk properties, resulting in altered material behavior. Materials at such small scales are also dominated by quantum effects. This gives a unique opportunity to scientists and engineers to develop applications based on the novel quantum properties. Nanotechnology has been labeled as enabling technology creating new applications in medicine, energy, industry, foods and consumer goods.

148. The developed as well as some of the developing countries have realized the potential of nanotechnology and have invested heavily in setting up specialized centres of excellences in various disciplines of nanoscience and nanotechnology. These countries have launched “National Nanotechnology Initiatives (NNI)” to develop and harness the potential of nanoscience and nanotechnology. The United States was the first one to do so. Now almost all developed countries have their own NNIs. Among Muslim countries, Iran has paid special attention by setting up a Nanotechnology Initiative Council in 2003, which is currently working directly under the Vice President for Science and Technology. Iran has attained 14th position in the world with respect to nanotechnology products. The US investment in nanotechnology has crossed USD 7Billion and total World investment has crossed USD 20Billion. It is estimated that by 2015, 18% of the total consumer products will have one or the other kind of nanotechnology involved in it. The total expected revenues by 2015 are estimated to be around 2.5 trillion dollars. This would be in nanomaterials, devices and tools. Currently, over 600 firms in more than 25 countries are involved in producing more than 1000 such products. The number of patents awarded each year has already crossed the 3000 mark.

149. The countries at the forefront of nanoscience and technology are USA, Japan, Germany, South Korea, Taiwan, China and UK.

Other countries close to catching up are Russia, France and Israel. India has also invested heavily in nanoscience and nanotechnology. The objectives of Indian “Nano Mission” are to promote basic research, establish international collaboration, conceive projects with private-public collaboration and human resource development in nanotechnology. They have established 3 institutes of nanoscience and nanotechnology, 7 centres of nanoscience & nanotechnology and 11 clusters of nanoscience and nanotechnology.

150. In Pakistan, the situation is rather dismal. Pakistan is lagging behind despite having a good infrastructure. Certain pockets of expertise exist because of the earlier funding by HEC and MoST but these are scattered. A National Commission on Nano-Science and Technology (NCNST) constituted in 2003 is now defunct. It is high time to revitalize the Commission with a task to develop the “National Nanotechnology Initiative” and bring all the stake holders in public and private sector on board to develop a roadmap for these technologies. The resources must be pooled to address the problems of the country in energy, environment, and health. Institutes of Nanoscience and Nanotechnologies need to be developed and equipped with the state of the art equipment. The private sector must be asked to contribute in the research funding of the projects directly or indirectly related to industry (on the lines of ICT R&D Fund).

Policy Actions:

- A107. Revival of National Commission on Nano-Science and Technology for launching of National Nanotechnology Initiative.
- A108. Setting up of National Institutes of Nanoscience and Nanotechnology to develop projects with private - public partnership.
- A109. Enhancing the capabilities of the existing laboratories to develop nano-technology products and train manpower with relevant expertise.

A110. Setting up a research fund for developing products using nanotechnology and their commercialization.

8.15 Lasers & Photonics

151. Lasers have been put to extensive use in almost every field of human activity including defense, energy, communications and information processing, data storage, entertainment, manufacturing and materials processing (cutting, shaping, drilling, welding, surface hardening), micro-machining, catalyzing chemical processes, environmental monitoring and remote sensing, therapeutics medicine, surgery, cosmetic and medical technology, analytical and forensic science, biosciences, printing, barcode reading, and in other basic scientific as well as industrial research. This list is expected to grow further in the future as new applications are discovered. In fact, no other scientific discovery of the 20th century has demonstrated so many varied and exciting applications as laser has.

152. Compared to developed countries, Pakistan is far behind in developing and adopting laser technology (specialized education, indigenous production of lasers and their use, related instrumentation and R&D). Due to the extensive range of applications, international manufacturers of Lasers and Optics have a yearly turnover of several tens of billions of dollars. However, like many other domains, access to some laser sources and specialized parts is usually denied. It is therefore, necessary to develop indigenous expertise irrespective of the cost considerations. Though some work has been initiated in strategic organizations on fabrication of some parts of lasers on a limited scale, reliable operation of laser systems remains a challenge. This necessitates a major initiative for establishment of an independent Institute of Lasers and Photonics outside the strategic organizations. The primary focus, in the beginning, could be on capacity building in terms of training and producing highly skilled manpower (scientists, engineers and technologists) together with development of facilities

leading to design and fabrication of prototype laser systems, optical components, and some related instrumentation. Additionally, creating awareness about laser technology in the public and promotion of use of lasers in our local industry should be part of the mission of this Institute. Finally, carrying out internationally competitive and relevant applied and basic research to stay up to date with new developments in this important field and its evolving applications, and to transfer its benefits to the country should be the ultimate focus. Publishing research and technical reports, journal and conference papers, and securing intellectual property rights through patents, should be the key performance measures. Organizing workshops, conferences, training courses and public lectures should also be a part of the mission of this institute.

Policy Action:

A111. Setting up of an Institute for Lasers and Photonics as part of a National Programme on Lasers and Photonics with the following goals in view:

- i. Educational and Training Programmes
- ii. Technology Transfer along with Indigenous R&D
- iii. High Quality and Relevant Basic and Applied Research
- iv. Business Development and Outreach for Industrial Partnerships
- v. Public Awareness Drive
- vi. Workshops & Conferences

8.16 Engineering Sector

153. The engineering disciplines have a broad range covering all facets of social and economic activities. The engineers are rightly regarded as builders of nations, since the engineering products and services are the most tangible objects of development activity. Industrialized countries depend on their engineers to earn foreign exchange that increases national wealth and

enables governments to provide civic facilities to its citizens. Engineering products are also the ones where the role of technology is most obvious. The prosperity of any country is strongly dependent on the robustness of its engineering and production sectors. Pakistan is endowed with a large pool of young manpower which is hard-working and talented as evidenced by their performance in international labour market. The existing industrial infrastructure in the country has enormous potential of export earning, but is marred by multifarious problems of management, innovation, energy supplies, unfavorable local and international regulations, high interest rates etc.

154. A joint study by Higher Education Commission and Pakistan Institute of Development Economics (PIDE), initiated in 2003, has thoroughly analyzed the industrial capacity of the country and proposed direction for the future developments. The document is entitled "Technology-based Industrial Vision and Strategy for Pakistan's Socio Economic Development" (2003). As noted in the preface of this report, it is "based on in-depth analyses of major productive sectors of the economy, the

report identifies key issues and challenges, sets out strategic objectives and targets, and spells out detailed action plan to realize the desired goals". Some of the sectors that have been covered are Agriculture, Textiles, Leather Industries, Materials, Chemical Process Industry, Engineering goods, Electronics, Energy, Telecommunications, Information Technology, Construction and Housing and Transport.

155. Considering that the document mentioned in the above para is a result of the efforts of a large number of Pakistani experts in different fields over a period of two years, the ST&I management system should ensure that the recommendations made in the report are implemented. The following action is envisaged in this respect.

Policy Action:

A112. Help and support for the implementation of the proposals documented in the joint reports of HEC and PIDE, entitled 'Technology-based Industrial Vision and Strategy for Pakistan's Socio-economic Development, 2003'.

Consolidated List of Policy Actions



Consolidated List of Policy Actions

Chapter - 2 : Vision and Objectives

- A1. Declaration of the political will that S&T capacity building would be a central pillar of national development strategy and the R&D expenditure would be enhanced to 1.0% of GDP by 2015 and 2.0% by 2020.
-
- A2. Commitment to create a long-term non-partisan ST&I policy with the consensus of all stakeholders and putting in place a legal framework for ensuring continuity of the policy and allocation of required funds.
-
- A3. Issuing the guidelines for shifting the focus of R&D towards demand side with full participation of private sector and employing mechanisms to foster innovation.
-

Chapter - 3: S&T Planning and Management Structure

- A4. Re-composition of NCST and ECNCST
-
- A5. The establishment of PCST as an autonomous body through an Act of Parliament.
-
- A6. Establishment of a well-staffed ST&I Policy cell in PCST.
-
- A7. Coordination with the Provincial Governments to establish and operationalize provincial Departments of Science and Technology.
-
- A8. Strengthening of Technical Wings in the Ministry of Science and Technology for evaluation and monitoring of R&D activities.
-

Chapter - 4: Human Resources

- A9. Review of syllabi for science at primary level with emphasis accorded to development of creative thinking and problem solving skills.
-
- A10. Enhancement of teachers' skills and approaches concerning 'how to teach science'.
-
- A11. Motivational programmes for students to engage in creative activities.
-
- A12. Schemes for invoking interest in science and acquisition of relevant knowledge at the very early age.
-
- A13. Development of the curricula at secondary and higher secondary levels in such a manner as to increase interest in science and technology among the students.
-
- A14. Ensuring the availability of qualified and trained teachers at secondary and higher secondary schools for teaching of science subjects.
-
- A15. Provision of fully equipped science laboratories at schools to demonstrate the curricula related experiments.
-
- A16. Devising counseling programme for students to help select the science subject more appropriate to their aptitude.
-
- A17. Access to scientific, engineering and technical higher education to be increased by enhancing the existing facilities and establishing new institutions.
-

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- A18. The quality of education to be enhanced through provision of qualified faculty, up-gradation of labs, and access to scientific information.
-
- A19. Attracting talented students with an aptitude for research by providing assured career opportunities in academia, industry and other sectors.
-
- A20. Development of mechanism for linkage and mobility of professionals among the academia, industry and research institutions.
-
- A21. Promotion of applied research through technology incubation and business development centres at educational and research institutions.
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- A22. Expansion of the network of technical training facilities.
-
- A23. Standardization of the training programmes to bring them at par with the internationally recognized qualifications.
-
- A24. Regulation of the “Madrassh Education system” and ‘Ustaad’ system of skill development.
-
- A25. The programmes under National Skill Strategy Policy to be integrated into S&T development system.
-
- A26. Creation of a single scientific and engineering cadre for all employees of MoST organizations on the basis of SPS – pay scales.
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- A27. Granting of autonomy to the S&T organizations under Ministry of Science and Technology and adoption of uniform rules, and regulations with performance based promotion criteria.
-
- A28. Enlarging the scope of prizes and awards for individuals and organizations making important contributions towards S&T development and public awareness of their achievements.
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- A29. Helping scientists in the process of patent registration and sharing of profits of commercialized products.
-
- A30. Coverage of scientific lectures, meetings and reports on electronic and print media.
-
- A31. Strengthening PSF programmes and outreach for effective dissemination of information evoking public interest in science through, inter alia, science caravans and exhibitions.
-

Chapter – 5: Indigenous Technology Development

- A32. Constitution of a task force with a number of sub-committees to propose specific actions with the identification of agencies responsible for executing these actions in order to achieve the following results.
-
- i. Establishment of close linkages between industries and R&D institutions/universities.
 - ii. Incentives for scientists working on industry-related projects.
 - iii. Induction of high-quality manpower from abroad for addressing local industry issues.
 - iv. Technical support to SMEs for enhancing the quality of their products based on indigenous resources.
 - v. Establishment of technology incubation centers in R&D organizations.

- vi. Prioritization for rapid development of selected industries with highest economic benefits.
 - vii. Analysis of reverse engineering potential and relevant issues, with recommendation of execution plans.
 - viii. Collaboration with foreign production sector to learn best practices.
 - ix. Improvement of MSTQ system.
 - x. Granting enhanced financial autonomy to R&D organizations.
 - xi. Motivating big industrial enterprises to set-up research wings.
 - xii. Establishment of new R&D organizations in multi-disciplinary areas.
 - xiii. Improving lab and field facilities of existing R&D organizations/ universities and creation of a database of equipment for sharing the laboratory resources.
- A33. Attracting FDI in advanced technology production through financial incentives and provision of physical infrastructure.
-
- A34. Ensuring the availability of local manpower suitable for absorption in high tech companies.
-
- A35. Devising a public procurement policy that gives preference to indigenous products and processes.
-
- A36. Utilizing the know-how developed by a large pool of highly qualified manpower in strategic organizations for industrial applications.
-
- A37. Developing simple technologies for relieving the concerns of deprived sections of society, related to water, energy, housing, hygiene etc.
-
- A38. Taking steps to enhance the share of cottage industry in national economy.
-
- A39. Establishment of a body under MoST for the codification of indigenous knowledge and its effective use in production sector.
-
- A40. Creating the position of a Liaison Officer in the Ministry of Science and Technology to coordinate the IPR related activities across all R&D organizations in close association with IPO, Pakistan.
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- A41. Establishment of Innovation Fund to sponsor projects based on innovative approaches to enhance productivity.
-
- A42. Coordination with the financial institutions of the country to install Venture Capital schemes with public-private partnership.
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- A43. Devising rules concerning the availability of private equity funds to public sector organizations.
-

Chapter – 6: Technology Transfer and the Creation of Absorptive Capacity

- A44. Provision of funding for increasing absorptive capacity of public and private production sector.
-

A45. Tax incentives for firms those are able to integrate into Global Production Networks.

A46. Directives for negotiating international trade agreements to ensure technology transfer.

A47. Offering of incentives to achieve reverse brain drain.

Chapter – 7: International Cooperation

A48. Designation of a 'monitoring team' for periodically reviewing progress on bilateral MoUs and dissemination of relevant information to research institutions and ministries.

A49. Ensuring strong participation in multilateral scientific fora.

A50. Capitalizing the scientific leadership role provided by Pakistan based IGOs.

Chapter – 8: Thrust Areas

Metrology, Standards, Testing and Quality (MSTQ)

A51. Setting up NPSL as the National Metrology Organization as a separate entity, independent of PCSIR (subject to the enactment of a single cadre for employees of scientific organizations under MoST).

A52. Strengthening PNAC and PSQCA in terms of manpower and infrastructure in order to enhance their roles of accreditation and standardization, respectively.

A53. Restructuring PSQCA and redefining its functions to remove jurisdictional overlap with the functions of NPSL and PNAC through amendments in the PSQCA Act.

A54. Increasing the number of mandatory standards manifold from its current figure of 85. These standards should also be enforced on imported goods to prevent the local market being flooded by sub-standard goods of foreign origin.

A55. Harmonizing federal and provincial laws to ensure that the same standards are uniformly applicable throughout the country.

A56. Involving the provincial setups in the enforcement of Pakistan Standards and strengthening them adequately for this purpose.

A57. Increasing the number of ISO/IEC 17025 accredited laboratories and certification/inspection bodies in various sectors in the country to facilitate the availability of internationally acceptable accreditation to the exporters, and launching of new accreditation schemes on ISO/IEC 17024, ISO/IEC 17043, Product Certificate ISO/IEC Guide 65 and PS 4996:2010 for Halal Certificate.

Environment

A58. Development of cost effective sewage treatment plants.

A59. Development of Industry-specific biotechnological waste-water treatment processes.

A60. Power generation through incineration of solid waste.

A61. Development of catalytic converters for retrofitting vehicles for minimizing the emission problems.

A62. Assistance in meeting the objectives of Environment Policy – 2005, which inter alia, aim to:
vii. Phase out sulfur from diesel and furnace oil.

- viii. Establish cleaner production centers and promote cleaner production techniques and practices.
- ix. Provide alternate sources of energy, like piped natural gas, Liquefied Petroleum Gas (LPG), solar energy and micro-hydel power stations, to the local inhabitants to reduce the pressure on natural forest, and to substitute firewood in the upland ecosystems.
- x. Promote the use of ozone friendly technologies; and phase out the use of ozone depleting substances in line with the provisions of the Montreal Protocol.
- xi. Promote recycling of agricultural products associated with livestock production and use of livestock sector as an outlet for recycling of appropriate urban waste.
- xii. Introduce adequate animal waste management system in peri-urban dairy colonies.

Health and Pharmaceuticals

- A63. Development of R&D capacity for producing active drug components and upgradation of drug quality testing laboratories.
- A64. Necessary steps for PCSIR, Peshawar to be WHO recognized Herbal Medicine Centre.
- A65. Establishment of new facilities for vaccines production and manufacturing of medical instrumentation and diagnostic equipment, for local needs as well as export purposes.

Energy

- A66. Harmonizing the efforts made in the energy sector by different Ministries, departments and research centres by creating an 'Energy Council' with heads of relevant organizations. The Council will be entrusted to advise on priority areas for R&D and management of resources and to fill the gaps.
 - A67. Acquisition of technology for building nuclear power reactors through R&D as well as transfer of technology agreements.
 - A68. Constituting R&D task force for developing processes to convert Coal and Coal gas for environment-friendly energy productions and their conversion to economically useful products.
 - A69. Development of pilot projects and their large-scale dissemination based on existing technologies such as solar water heaters, biogas plants, photovoltaic etc.
 - A70. Announcement of incentives (e.g. tax holiday) to the private sector for the manufacturing of renewable energy products, components and systems, such as solar thermal power system components, wind energy technology components, biogas plants etc.
 - A71. Creation of a 'Renewable Energy Fund' for research into the development of new RE technologies such as hydrogen fuel cell, Fresnel mirrors and low-cost/high-efficiency photovoltaic panels.
 - A72. Ensure utilization of alternative energy sources and get adequate allocation for actualization of provincial projects/plans.
 - A73. Biotechnology and Genetic Engineering
Re-establishment of 'National Commission on Biotechnology' and charging it with the task of coordinating nation-wide research programmes in different areas where biotechnology can be applied.
 - A74. Reviewing the draft of 'National Biotechnology and Genetic Engineering Policy and Action Plan' and implementing it with the support of relevant organizations.
-

A75. Enacting biotechnology related legislations.

A76. Establishment of biotechnology incubation centers.

Agriculture and Livestock

A77. Development of genetic modification expertise for producing high yield/ pest resistant crops.

A78. Using new technologies such as remote sensing, laser land-levelling, bio-fertilizers and solar tube-wells for enhancement of efficiency in the sector of farm produce.

A79. Producing, preserving and processing fruits and vegetables that satisfy food-chain requirements of the international market.

A80. Establishing facilities for producing quality controlled Halal food for Muslim consumers in different parts of the world.

A81. Supporting schemes for modern techniques in poultry, livestock and fish farming.

Water

A82. Providing help and support for the implementation of 'National Water Policy - 2009' and 'National Drinking Water Standards'.

A83. Completion of projects for establishing water treatment plants in all union councils.

A84. Implementation of water conservation technologies and assistance in the promulgation of the Water Conservation Act.

A85. Development of inexpensive techniques for water desalination and purification for domestic use, and treatment of waste water.

Minerals

A86. Provision of support for the implementation of National Minerals Policy 1995.

A87. Undertaking R&D work for utilizing the full potential of coal reserves.

A88. Development of technologies for processing different indigenous ores to extract products of high commercial value.

Ocean Resources

A89. Mapping of oceanic resources in the maritime Exclusive Economic Zone as well as under seabed for assessing the potential of their utilization.

A90. Exploitation of tidal energy potential and sea-based minerals such as manganese nodules and gas hydrates.

A91. Development of sea-based aquaculture and fishery industry.

Electronics

A92. Launching of specific programmes for the automation of local industry.

A93. Setting-up Electronics Facilitation Centres for providing advice, training and services to support production of electronics goods and electronics-based equipment.

A94. Information and Communication Technologies (ICTs)
Support for the implementation of the IT Policy and Action Plan.

- A95. Establishment of public ICT Industrial Parks.
(There are number of existing IT / ICTs parks but the proposed ICT industrial parks will consist of many national level sub-parks and technical support bases, including; micro-electronics industry, software industry export base, software industry base, semiconductor lighting (light emitting diode - LED) base, information security base, IC design industry base, electronic information industry base, IC design park, multimedia industry park, multimedia valley, digital media industry park, international outsourcing park, opto-electronics industrial park, panel display industry base & support software parks).
-
- A96. Deploying ICT across sectors to improve the sectoral growth, e.g. SMEs to be encouraged to use ICTs for improvement of their competitiveness.
-
- A97. Supporting e-commerce and e-governance applications.
(Many countries in Asia are taking advantage of e-commerce through opening of economies, which is essential for promoting competition and diffusion of Internet technologies).
-
- A98. Encouraging entrepreneurial activities such as offshore low-cost Business Processing Centres.
-
- A99. Promoting open source software.
(The establishment of a central body is recommended to develop and monitor standard, free open source software that can be implemented in all public offices and education institutes. This will help in saving handsome amount that is being given against purchase of annual licenses. In this regard, Indonesia's model can be adopted. Indonesia has more than 90% of Govt. offices on locally maintained open source software).
-
- A100. Sharing of ICTs resources to meet large volume computing.
(There is a need to introduce and support shared ICT services (like web platforms against security threats, information portals, development of street views) and provide large volume computing services (by installing super computers for public use by large entrepreneurs / multinationals). Service can be provided on rental basis to ensure sustainability of the service).
-
- A101. Offering ICT-related financial incentives (tax holidays/introduction of special tax rates for software exporters etc.).
-
- A102. Establishment of the citizen-centered e-state and development of the framework for customer-friendly business-to-consumer and business-to-business services.
-
- A103. Making further improvements in liberalization of telecommunications market, well functioning regulatory environment and high level national education in ICTs.
-
- Space Technology*
- A104. Launching of a coordinated effort by all relevant R&D and higher education institutions to develop indigenous satellites and expertise pertaining to space technology.
-
- A105. Setting-up institutional linkages of MoST with SUPARCO and IST.
-
- Materials Science*
- A106. Establishment of a National Materials Science Research Institute with a centralized super-computing facility for computational materials science or condensed matter physics.
-

Nanoscience and Nanotechnology

A107. Revival of National Nano-technology Commission or launching of National Nanotechnology Initiative.

A108. Setting up of National Institutes of Nanoscience and Nanotechnology to develop projects with private – public partnership.

A109. Enhancing the capabilities of the existing laboratories to develop nano-technology products and train manpower with relevant expertise.

A110. Setting up a research fund for developing products using nanotechnology and their commercialization.

Lasers & Photonics

A111. Setting up of an Institute for Lasers and Photonics as part of a National Programme on Lasers and Photonics with the following goals in view:

- i. Educational and Training Programmes
 - ii. Technology Transfer along with Indigenous R&D
 - iii. High Quality and Relevant Basic and Applied Research
 - iv. Business Development and Outreach for Industrial Partnerships
 - v. Public Awareness Drive
 - vi. Workshops & Conferences
-

Engineering Sector

A112. Help and support for the implementation of the proposals documented in the joint report of HEC and PIDE, entitled 'Technology-based Industrial Vision and Strategy for Pakistan's Socio-economic Development-2003'.
