Science
Technology &
Innovation
Strategy
2014-18

Pakistan Council for Science and Technology
Ministry of Science and Technology
Government of Pakistan

CONTENTS

MESSAGE OF THE FEDERAL MINISTER FOR S&T

The need for Pakistan to recognize the importance of science and technology for economic growth, in the real sense, has become even more pressing as the world is changing at a rapid pace, driven by accumulation of scientific knowledge & its technological applications and lightning-fast advancements in ICTs. To reap benefits of these developments, we need to pay adequate attention to the capacity-building in science and technology as it is the engine that drives knowledge-based developments. Development of our R&D infrastructure & human resources and provision of proper governance and regulatory framework have become a must. Otherwise, we will further lag behind the industrialized nations as we will fail to apply scientific advances and new technologies creatively.

Economic revival is on the top of the agenda of the present government which is evident from the slogan “Strong Economy -- Strong Pakistan” which is written on the manifesto of the PML (N)-the major ruling party. However, Science and Technology has also been given due place in its manifesto which represents a strategic shift from the prevailing piece-meal approach to a holistic STI strategy. STI strategy of the government focuses on the rapid development of human resources and providing meaningful employment to a growing young, educated segment of the population. In addition to the traditional fields of Science & Technology, the policy focus represents a paradigm shift in R&D in emerging technologies and its strategic exploitation through commercialization opportunities to create new companies, new solutions and new jobs.

Development of appropriate strategies is important but putting them into practice is even more important. Although Pakistan does not have proud history of implementing the policies and plans, and implementation of S&T policies and strategies is even more difficult as it is different, due to its cross-sectoral nature, than traditional policies such as policies in health, agriculture, education sectors etc. However, Ministry of Science and Technology, with support of the other stakeholders, will leave no stone unturned in implementing the STI Strategy 2014-18 in order to implement the Prime Minister’s vision and agenda for national development.

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PREFACE

Scientific knowledge is the bedrock of modern technology, which in turn, is the foundation on which the economic prosperity of industrialized countries is based. It is, therefore, inevitable that any country wishing to embark upon a course of economic development has to achieve a high degree of expertise in different sciences and the know-how of their technological applications. Both of these capabilities require engagement in Research and Development (R&D) activities by a substantial fraction of educated manpower of a country. Obviously, the infrastructure and facilities for such activities has to be provided by the State or the private sector. Currently, Pakistan has too few people engaged in R&D 148 researchers (Full-time Equivalent) per million as against 2000-5000 in developed countries and the national financial input across different sectors for R&D activities is far too small (around 0.56% of GDP). In the highly competitive world markets, governed by WTO rules that provide limited space for protectionism, it is not a matter of option to allocate adequate resources for the development of R&D capabilities in the domain of Science and Technology.

The Ministry of Science and Technology considered it expedient to devise a practicable strategy for the next five years in order to achieve well-defined goals, consistent with its priorities. In the strategy, identification of specific achievable goals has been made in light of the ‘Science and Technology’ vision of the present government, as outlined in pre-election manifesto of the ruling party. The statement of the goal is followed by a brief introduction of the relevant sector. In the third section, a number of specific ‘targets’ have been stated which the Ministry of Science and Technology will try to accomplish in order to achieve the relevant ‘goal’. Hence, the present document provides the basis on which developmental work in the Ministry of Science and Technology will be undertaken during the next five years.

On the basis of the functions of the Ministry of Science and Technology given in the Rules of Business, and keeping in view priorities of the present government, a detailed ‘Action Plan’, for the next three years, has already been prepared for MoST as well as for all the organizations working under its administrative control. The ‘Action Plan’ gives performance targets, time lines to achieve these targets and responsibility of the concerned section / department / officer incharge.

The major performance targets of the Ministry of Science & Technology indicated in the action plan are as under:-

1. Develop new holistic S&T strategy, reorienting R&D towards market requirements and enhancing its contribution to national socio-economic development.
2. Improving governance and performance of R&D organizations through installation of highly qualified professional leadership.
3. Establish "Innovation Incubators" in every major school of S&T.
4. Establish "Technology Clusters" in major cities with collaboration of Provincial Governments.
5. Establish Centres of Excellence in Nanotechnology, Biotechnology and Fuel Cell Technology.
6. Establish cell in MoST to promote the emerging technologies.
7. Outlining priority research areas for need base research.
8. Commercialization of R&D activities – Development of Linkages between Academia, R&D Organizations and industry through MOUs.
9. International collaboration with friendly countries for technology transfer to and capacity enhancement in R&D Organizations.
10. Exploitation of indigenous resources and technologies for industrial development and providing solution to industrial problems.
11. Promotion of affordable Renewable Energy Technologies.
12. Create capacities in PSQCA, PNAC, NPSL etc. to promote quality culture for trade enhancement.
13. Emphasize Human Resource Development through utilization of facilities available under international bilateral programs and award of scholarship / fellowship in collaboration with HEC.
14. Incentivize R&D activities through institution of awards / prizes.
15. Enhance coordination with provincial Governments and S&T departments.

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1. INTRODUCTION

The role of Science and Technology in the economic transformation of the countries is well recognized. However, it can play this role only if scientific advancement and technological development is governed by well-thought out properly-defined and smartly planned guidelines in the form of S&T strategies. The transformation of Korea from a stagnant agrarian society into one of the most dynamic industrial economies of the world within a few decades is a prime example in this regard. In 1960s, Korea's total exports were 4 times less than Pakistan, but now its exports are 25 times more than Pakistan. It has become world's 13th largest economy with a GDP of 1.467 Trillion US dollars. When Korea decided to make R&D and innovation backbone of its industrialization efforts, it was a typical poor developing country with poor resource and production base, small domestic market, and a large population. Now, it has achieved a prominent position in technology areas such as semi-conductors, LCD, telecommunication equipment, automobiles, shipbuilding etc. It has emerged from nowhere as one of the key international players in the global economy. It is said that in three decades, Korea has achieved what it took more than a century for the Western industrial countries to accomplish.

There was some realization about the importance of science and technology in Pakistan, right from the beginning, for its security as well as for socio-economic development. The National Scientific Commission of Pakistan was constituted in 1960 and the first "National S&T Policy" was approved in 1984 which was followed by the "National Technology Policy and Technology Development Plan - 1993". However, it is still argued by many in Pakistan that we cannot afford to invest in science and technology and any such action, is seen as a luxury rather than a need. The argument is that we should invest for solutions of our more immediate concerns related to agriculture, public health, education, employment, population control etc. rather than S&T with the aim of long term benefits. We must understand as a nation that going for immediate solutions without long-term capacity building with respect to the pillars of development and economic growth is just like 'giving someone a fish instead of a fishing pole'.

Many countries are now recognizing the importance of investment in science, technology and innovation which acts as an engine for long-term development. They are realizing that if they have the desired level of S&T capacity, only then they will be able to identify, adapt, and effectively use the S&T achievements of industrialized nations and develop their own unique technologies. Resulting in better application of technologies to improve many aspects of social and economic development—from pest-resistant crops to less wasteful food processing; from prenatal care and child health to the prevention and treatment of diseases; from reduction of environmental contaminants to purification of water; and from more reliable electricity to more efficient and affordable communication and transportation systems.

Undoubtedly, the higher levels and rates of growth enjoyed by some advanced countries are attributable to the greater success of those countries in exploiting emerging technological opportunities. Emerging technologies present a wide range of opportunities for developing countries, like Pakistan, which can be tailored according to their own societal and environmental needs. However, in order to benefit from these technologies they need to adopt a systematic and focused approach. The lagged growth in the these sectors in developing countries is generally attributed to the allocation of insufficient financial resources, lack of highly qualified & skilled manpower and lack of appropriate policies needed for the development of this sector. The technological change in developing countries is generally incremental rather than radical. Therefore, the degree to which they can benefit from new and emerging technologies depends on their level of preparedness to accept and make use of these technologies. Technology Achievement Index (Nasir et al., 2010) suggests that most of the developing countries are not well prepared for the adaption of new technologies. Pakistan has been placed 86th in the ranking of 91 countries. The newly industrialized countries of Southeast Asia are ahead in the race of adaption of new technologies than most of the other developing countries because of their previous accumulation of technological capabilities. Therefore, wholehearted efforts will be needed to achieve world prominence in these technologies.

In the new global economic scenario, the growth and development of economy of a country will depend on its competitiveness in the global market which in turn will depend upon its ability to innovate and to utilise these innovations through commercialization for achieving economic and social benefits. If Pakistan has to successfully transform its economy into knowledge-based economy, all the major stake holders, government, universities, public sector R&D organizations and industry, need to be aware of their respective roles. Especially, universities and R&D organizations should realise their role in knowledge generation, knowledge exploitation and knowledge transfer while government should formulate policies, provide finances and instruments to stimulate collaboration between academia / researchers and industry.

2. VISION AND OBJECTIVES

2.1. Vision

To accomplish socio-economic prosperity, national security, equitable & sustainable development and global competitiveness through science, technology & innovation-driven knowledge-based economy.

2.2. Main Objectives of the S&T Strategy

The main aims and objectives of the S&T Strategy 2014-18 are 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 strategy 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.

The principal aims and objectives of the Science and Technology Strategy are:

- A strategic shift from the prevailing piece-meal approach to a holistic S&T strategy.
- Rapid development of human resources as per future need of the country.
- Improved communication, coordination and collaboration among S&T, ICT and other sectors of socio-economic development.
- Focus in Research & Development in emerging technologies and its strategic exploitation through commercialization of research results, discovering new solutions and creating new companies.
- To improve performance of existing R&D institutions and creation of new, well-equipped, multi-disciplinary research facilities at national level in areas of traditional and emerging technologies..
- To ensure that Pakistan acquires world-class expertise within 5-years in the emerging technologies i.e. biotechnology, nanotechnology, renewable energy technologies & fuel cell.
- 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.

- To establish a network of innovation incubators & holistic technology clusters and technology fund for promoting indigenous technology development, innovation and entrepreneurship.
- Ensuring good governance in S&T organizations through merit based appointments of heads of organizations and monitoring & evaluation of their research output.
- Establishment of S&T Policy Research Institutes to act as think tanks in different areas.
- Enhancing the national R&D expenditure upto 1.0% of GDP by 2015 and 2.0% by 2018 for building capacity in S&T that would be a central pillar of national development strategy.
- Providing meaningful employment to a growing young, educated segment of the population and create one million new jobs within 5-years that will enhance socioeconomic development.

The goals and targets given in the following sections of the present document have been derived from the manifesto of the ruling party, Science, Technology and Innovation Policy 2012 and above-mentioned Action Plan keeping in view priorities of the present government and functions of the Ministry of the Science and Technology. It is envisaged that implementation of the present strategy will, *inter alia*, make significant contributions in providing solutions to the key challenges faced by Pakistan in the following areas:

- Energy
- Water
- Food Security
- Health
- Unemployment
- Export Enhancement
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3. PARADIGM SHIFT IN S&T

Pakistan will not be able to exploit or sustain its competitive advantage in an increasingly competitive global market if it continues to neglect investments in human capital and building capabilities of technical change. It is a well-established fact that more than half of the economic growth in developed countries is due to technology capabilities. Pakistan needs to implement a STI policy, which is coordinated with all other development policies in particular education, health, agriculture and industrial policy to achieve its development goals.

Policies do not show results unless they are formulated on evidence informed research and are supported by political will and financial investments. Technology and innovation policy can only work effectively in a country where there is macroeconomic stability, rule of law, good governance, a competent bureaucracy selected and promoted on merit and continuation of investment policies for social and industrial development. STI policies have also limited impact in markets where monopolies and cartel formation is encouraged and where competition and consumer protection laws either do not exist or have weak applications.

3.1. STI Strategy

1. A strategic shift from supply driven S&T towards meeting demand of the social and economic sectors. Promotion of incremental and organizational innovations for achieving technology capabilities in strategic areas such as agriculture, water, energy and health technologies.
2. Addressing rural and urban poverty by investing in infrastructure technologies such as education, health, sanitation, transport and information in rural areas where almost 70 percent of population resides (Pakistan is signatory to meeting Millennium Development Goals).
3. Investment in large technology projects such as the Torch Program of China to address rural poverty through provision of seed money for farmers to promote agro- based industry and introduction of modern technology for productivity growth. Bridging productivity gap between large and small farmlands.
4. Local production of Vaccines for animals and human use. (Only 10 percent of animals in Pakistan are vaccinated despite a number of animal vaccines developed by local institutions). Local pharmaceutical firms involved in import and distribution of Vaccines should be provided incentives to work with local R&D organizations and with international firms for local production of vaccines.

The government should encourage this project with public purchasing guarantees provided the Vaccines meet WHO standards.

5. Investment in human capital for training of high quality scientists, engineers, technicians, researchers and managers, linking training with market demand. Emphasis on building new or strengthening of existing technical schools such as Pak/Swiss training center in industrial cities.
6. Attract additional private investment in higher education with a condition that 50 percent of the students from poor or deprived background will be provided complete scholarships. In two private universities in Turkey (Heceteppe and Bilkent), half of the students are enrolled from deprived background and receive scholarships for tuition fee, books as well as boarding and lodging. Almost 85% of expenditure on higher education in South Korea comes from private sources.
7. Build knowledge clusters (cluster of universities, R&D organizations, including organizations providing standards and testing services, development banks and other financial institutions that provide venture funding, insurance and legal firms for settling corporate disputes in industrial cities) and colocation facilitates.
8. Improving infrastructure of R&D organizations with focus on strengthening of Metrology, Standards, Testing and Quality Control Organizations. MSTQ services need to be extended to all industrial cities.
9. Restructuring of R&D organizations which provides more autonomy with accountability, reduced bureaucratic control and regular performance evaluation of research and management personnel.
10. The heads of all R&D organization should have relevant qualification and experience. (Diaspora with relevant qualification and proven performance record should be invited to head R&D organizations).
11. R&D organizations under Ministry of Science and Technology should focus their efforts on applied and development research. The performance evaluation criteria of R&D personnel for further advancement in career need to change from current emphasis on international publications to their having designed and developed new prototype for products or processes, providing technical services to industry for sourcing, adoption and absorption of imported technology or for better organization of production, human and technical resources (organizational innovations).
12. Strengthening of existing institutions (such as PCST) and establishing new for conducting evidence informed STI policy research. This includes research on policy evaluation. Anticipation of future trends and development related to

innovation policy (future studies). Industry specific incentives and incentive policy.

13. Setting priorities in public research funding to achieve competence in few emerging technologies such as Information Technology, Biotechnology, Renewable Energy and Nanotechnology.

14. Creation of an Innovation fund for promotion of technology-based entrepreneurship.

3.2. R&D Strategy

1. Increase public R&D expenditure from present 0.33% of GDP to at least 1% of GDP by 2020.

   1a. The focus of R&D investment should shift from major share being currently spent on public R&D organizations towards building absorptive capacity of export firms. At least 60% of public R&D expenditure should be spent for stimulating industrial R&D through incentives.

   1b. Export oriented firms should be provided incentives (tax exemptions, R&D grants, double depreciation tax exemption for machinery and subsidies for adoption of international standards and value added production). Firms should also be offered tax incentives for training of personnel or hiring of R&D manpower (R&D grants and other incentives should only be offered to firms that need to be reviewed periodically to avoid firms becoming rent seekers).

   1c. Encouraging joint ventures (public, private) for technology based entrepreneurship. Technologies should be new to the market not necessarily new to the world.

   1d. Promotion of university, industry linkages through incentives to university researchers such as time spent in providing consultancy to industry counted towards their service, change in performance evaluation for promotion, internship programmes for engineers and management graduates in large firms and regulations for sharing of Intellectual Property between university and industry.

   1e. The contribution of private R&D to total R&D expenditure should increase upto at least 20% of total R&D expenditure in 2020.

2. Industrial transformation, shift to high technology knowledge based economy. Focus on engineering, ICT, Petrochemicals and Pharmaceuticals.

3. Concentration on export industry to increase productivity and competitiveness through efficiency and value added production.
4. Revival and expansion of production industry for value added textiles (Medical Textiles) and fashion garments, engineering and pharmaceuticals.

3.3. Institutional Reforms and Regulations

1. Strengthening of metrology, standard and quality control organizations and related infrastructure and ensuring their implementation mechanism in all provinces. Extension of MSTQ services to all industrial cities.
2. Legal instruments for protection of investments in local technology projects.
3. Technology transfer laws for local technology capability building.
4. Research Institutes and universities to develop their IPR policy.
5. Reforms in the patent system are required as IPO Pakistan has not delivered due to non-professionals heading this institution (politicians, retired bureaucrats).

3.4. Creating Demand for Local Technology

1. Industrial policies or strategic industrial visions create demand for technology. East Asian examples demonstrate the importance of such visions for local technology development.
2. Public purchasing is the most frequent and most efficient instrument of STI strategy used for local technology development. Public purchasing creates demand for technology and stimulates private R&D. The public procurement policy involves a public organization such as Ministry of Defence in case of Pakistan, which may place a contract with local firm ordering the development of a technology, which is not locally manufactured and which the investors believe could be developed locally.
3. A law for promotion of local technology development should be promulgated. where it should be made mandatory for all large public sector projects to purchase locally developed technology. We have lost several opportunities for local development of technology despite having established large engineering capacities such as Heavy Mechanical Complex, Heavy Electrical Complex and Machine Tool Factory.
4. International agreements should be seen as opportunity for local development, e.g. the agreements with the International Power Producers (IPPs) in 1992 should have included joint venture projects for local production of power plants.

5. Similarly, Mobile Phones could be manufactured at the Haripur laboratories if we had negotiated with any of the mobile companies for technology transfer in exchange for a percentage of market shares. This would have created additional jobs.
6. We had a carriage factory for local manufacturing of Railway-Carriages. Instead of entering into joint ventures for up-gradation of technology and investing in training of relevant design and production engineers for manufacture of modern carriages locally, we abandoned this factory in favour of imports from China.
7. We have recently spent huge amount of public budget for purchase of computers distributed to poor students in Punjab and other provinces. These computers should have been assembled in Pakistan with negotiations of local content requirements and technology transfer. South Korea's computer industry was developed following a policy of public purchasing.
8. FDI should be negotiated for setting up production units in joint venture in export processing zones for value added textiles, engineering and pharmaceutical industry. This will help in capital formation, technology transfer and learning of better management and marketing practices.

3.5. Technology Transfer Policy

Technology transfer in all sectors of the economy has to be promoted with regulations. Pakistan is the only country in this region where exports trends from consumer good in 1960 to capital goods production 2014 show reverse trends. We seem to have lost technology advantage in agriculture and some manufacturing sectors that we had acquired in the 1960s/1970s. The composition of our exports show a higher concentration of low value added goods compared to other regional competitors. Following channels may be utilized for technology transfer.

1. Training of scientists, engineers in technological advanced countries
2. Direct technology purchases through turn-key agreements or through licensing agreements from foreign suppliers
3. University- industry-linkages
4. Foreign Direct Investment
5. Patent information and technical articles

4. FRAMEWORK OF SCIENCE, TECHNOLOGY AND INNOVATION STRATEGY 2014-18

4.1. Development of human resource in science and technology

- *University education*
- *Technical and Vocational Education*
- *Service Conditions and Incentives for S&T Manpower*
- *Motivational Measures*

4.2. Improving science and technology structure for enhanced performance

- *Improving infrastructure for S&T policy and coordination among stakeholders*
- *Enhancing capabilities of managers of S&T organizations*
- *International Cooperation*
- *Role of women in science, technology and innovation*
- *Public awareness of science and technology*

4.3. Achieving excellence in emerging sciences and technologies

- *Nanotechnology*
- *Biotechnology*
- *Renewable Energies Technologies*
- *Materials Science and Lasers & Photonics*

4.4. Optimal utilization of established technologies

- *Information Communication Technologies (ICTs)*
- *Space Technology*
- *Ocean and Mineral Resources*

4.5. Technology and innovation support to industry for enhancing exports

- *MSTQ System*
- *Innovation and Technology Development*
- *Electronics*
- *Engineering*

4.6. Science, technology and innovation for social development priorities

- *Food Security*
- *Water*
- *Health and Pharmaceuticals*
- *Environmental Quality*

4.1. Development of human resource in science and technology

Focus Areas:

⇨ *University education*

⇨ *Technical and Vocational Education*

⇨ *Service Conditions and Incentives for Scientific and Technical Manpower*

⇨ *Motivational Measures:*

GOAL 1
Development of human resource in science and technology at all levels as per needs of the public and private sector

Development of human resources is the most important aspect of any science and technology strategy, 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, by 2011 Pakistan has only 149 (Full Time Equivalent). 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.

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. However, a national innovation system can deliver only if concurrent steps are taken in the areas of human resource development, basic and applied research, commercialization of research output and legal frame-work that protects the intellectual and financial investments of the firms.

University Education:

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.

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.

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.

Technical and Vocational Education:

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.

Unfortunately, the Technical and Vocational education is the weakest link in the S&T manpower chain. According to World Bank (2009) estimates (data.worldbank.org) 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 (2009) only 255,636 enrolled students across 3,125 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.

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.

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.

Service Conditions and Incentives for Scientific and Technical Manpower:

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.

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 criteria 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%.

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.

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.

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.

Motivational Measures:

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.

Targets

1.1. Access to scientific, engineering and technical higher education to be increased by enhancing the existing facilities and establishing new institutions.

1.2. The quality of education to be enhanced through provision of qualified faculty, up-gradation of labs, and access to scientific information.

1.3. Attracting talented students with an aptitude for research by providing assured career opportunities in academia, industry and other sectors.

1.4. Development of mechanism for linkage and mobility of professionals among the academia, industry and research institutions.

1.5. Promotion of applied research through technology incubation and business development centres at educational and research institutions.

1.6. Creation of a single scientific and engineering cadre for all employees of MoST organizations on the basis of SPS pay scales.

1.7. 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.

1.8. Enlarging the scope of prizes and awards for individuals and organizations making important contributions towards S&T development and public awareness of their achievements.

1.9. Helping scientists in the process of patent registration and sharing profits of commercialized products.

4.2. Improving science and technology structure for enhanced performance

Focus Areas:

- *Improving infrastructure for S&T policy and coordination among stakeholders*
- *Enhancing capabilities of managers of S&T organizations*
- *International Cooperation*
- *Role of women in science, technology and innovation*
- *Public awareness of science and technology*

GOAL 2

To improve Infrastructure for S&T policy at national and provincial levels and better coordination and collaboration between different stakeholders

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". Uptill now, NCST has not been able to achieve what was desired of it, however, potentially it is a very useful forum for giving direction and increasing volume of science and technology effort in the country. Achievements (significant improvement in the S&T status, especially in IT and Higher Education) as result of the 2nd meeting of NCST indicate that how effective the Commission can be if properly utilized. Major reasons why NCST has not achieved up to its potential are as under:

- Pakistan Council for Science and Technology (PCST) was not adequately strengthened to perform its role as secretariat of the NCST.
- There is a false impression that NCST is not a decision-making body which has resulted in creating lack of willingness in the Secretariat of NCST to exert its authority for implementation of the decisions of NCST.

NCST is a wonderful forum for coordination of inter-ministerial and inter-provincial S&T programmes and integration of S&T into the other sectors of economy. Its membership includes representation from all sectors of economy at the highest level with Ministers for Finance, Agriculture, Industries, and Education as its members along with provincial Ministers for S&T and Deputy Chairman, Planning Commission. Heads of all major R&D organizations (in various fields) and representatives of industry are also its members. Therefore, there is an urgent need to re-activate NCST.

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.

The other important components of existing planning and management structure for non-strategic Science and Technology sector at the national level are:

- Ministry of Science and Technology (MoST)
- Pakistan Council for Science and Technology (PCST)

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 its implementation. The enhancement of provincial autonomy under the 18th amendment (April 8, 2010) does not curtail the Ministry's role and functions.

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.

Both of these organizations need to adequately strengthened on urgent basis in order to enable them to perform their functions efficiently and effectively.

At the provincial level, the existence of full-fledged S&T departments is very important. 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.

Targets:

2.1. Re-activation of the Nation Commission for Science and Technology (NCST) and re-composition of NCST and its Executive Committee (ECNCST) keeping in view requirements of the current scenario.

2.2. Providing appropriate legal status to the Pakistan Council for Science and Technology which is the secretariat of NCST (establishment of PCST as an autonomous body through an Act of Parliament).

2.3. Strengthening of PCST in terms of human & financial resources and technical facilities, and establishment of a cell within PCST, wholly dedicated to deal with NCST matters.

2.4. Strengthening of Technical Wings in the Ministry of Science and Technology for evaluation and monitoring of R&D activities.

2.5. Coordination with the Provincial Governments to establish and operationalize provincial Departments of Science and Technology in all provinces.

GOAL 3

To fully avail collaborative opportunities with relevant international organizations in priority areas of science and technology by effectively utilizing bilateral agreements, Pakistan-based IGOs, diplomatic missions as well as other relevant forums.

Countries can achieve sufficient and relevant progress in science, technology and innovation only through co-operation beyond national boundaries. Realizing the importance of mutual cooperation, the Ministry of Science and Technology has signed agreements on S&T cooperation with more than 30 countries.

Bilateral cooperation

Pakistan and the United States have renewed science collaboration in a range of sectors like agriculture, university education, water and renewable energy. Pakistan‘s Ministry of Science and Technology (MOST) and the US government signed an agreement in 2003 to set up a framework for cooperation in science and technology. In 2005, USAID and Pakistan’s Higher Education Commission (HEC) joined hands with MOST in boosting science cooperation.

Bilateral cooperation is developing fast between China and Pakistan and both agree to jointly support the construction and development of the China -Pakistan Joint Maritime Research Centre and also have signed an agreement for cooperation on BeiDou Satellite Navigation System in Pakistan, and will make continual progress in the remote-sensing satellite system project.

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 neighbouring 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.

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.

Multilateral Cooperation

Multilateral cooperation in the fields of science and technology has the potential to strengthen relations between countries, promote goodwill, and expand the boundaries of knowledge. Multilateral cooperation of Pakistan with international partners could significantly increase the footprint of social, economic and health impacts. 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; trying to 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 has enabled Pakistani scientists to contribute in the construction of the CMS detector components and for carrying out research work at the new facility. Similar participation in other international projects of this kind will increase the visibility of Pakistani scientists as well as that of the country in the international scientific community.

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.

Pakistan is an active member of the Central Asia Regional Economic Cooperation (CAREC) Program working to promote and facilitate regional cooperation in the priority areas of transport, trade facilitation, trade policy, and energy. Asia Pacific Space Cooperation Organization (APSCO) has evolved from Asia Pacific Multilateral Cooperation in Space Technology and Applications (AP-MCSTA), which came into being when an MoU was signed between China, Pakistan and Thailand in 1992. The objectives of APSCO are to focus on space science / technology and its applications, education / training and cooperative research to promote peaceful uses of outer space in the region.

Pakistan is a growing market for life sciences and biotechnologies, and multilateral cooperation of Pakistan with international partners such as European Union (EU) could significantly increase the impact. Pakistan's biotechnology and medical research in academia is rapidly developing. University departments in Pakistan dealing with life science research amount to over 200, with increasing numbers in general and particularly in the biotechnologies and applied science sectors.

Targets:

3.1. Development of linkages between Academia, R&D Organizations and industry through MOUs both internationally and nationally.

3.2. International collaboration with friendly countries for technology transfer and capacity enhancement in R&D Organizations.

3.3. Emphasize Human Resource Development through utilization of facilities available under international bilateral programs and award of scholarship/fellowship in collaboration with HEC.

3.4. Develop International Linkage with various International Scientific/Research Societies to explore opportunities at regional and bilateral level.

3.5. Ensuring strong participation in multilateral scientific forums and establishing a general fund for this purpose on permanent bases with necessary flexibility for an operational use of allocations to S&T activities with different countries.

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

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

GOAL 4

To enhance productivity of S&T establishments and relevance of research to the society and economy through improving management of the organizations.

Science and technology activities greatly affect the lives of all citizens of a country. For example, the work conducted in R&D organizations helps to ensure the quality of the food and water that we consume and the environment in which we live. Other activities are aimed at generating wealth, creating jobs and improving the competitiveness of industries. R&D organizations also contribute to the generation of new scientific knowledge for the benefit of present and future generations.

The Government of Pakistan spends approximately US$ 575 million on science and technology activities. These activities are conducted for a variety of fields ranging from Food and Agriculture, Water, Health, Engineering, Environment, ICT, Energy and so on. They are divided into two principal components: research and development and related scientific activities.

Pakistan has established R&D organizations in almost every field of science and technology. Now when efforts are being made to set direction for science and technology activities, research organizations are being asked to set clear goals for their activities and focus more on output. They also need to set priorities based on a full recognition of the needs of their clients and of the opportunities in their respective sectors of activity. At present, there is no assurance that the activities they are performing and the means they have chosen to carry them out are the ones that provide the greatest benefits.

Therefore, more attention needs to be placed on business development activities. Almost all, if not all, research establishments in Pakistan need to improve their capability for identifying potential uses and users of the results of their research activities. I general, for these organizations, it is unclear how science activities can achieve the missions and objectives of organizations and the needs of clients when such clients are not adequately defined and their needs not adequately profiled. It has been observed that majority of organizations do not select and review projects in a rigorous manner and there are also major deficiencies in project management practices.

A key success factor, for ensuring that S&T organizations are play their due role in the socio-economic development of the country, is the proper management of the S&T establishments and their research programmes and projects. However, the inherent nature of research and development activities poses specific challenges to science and technology managers / heads of S&T establishments. For example, the managers are now facing an important challenge in attempting to increase the relevance and the economic impact of their activities and to do so they also have to face fiscal constraints.

For increasing the economic relevance of R&D activities, the R&D organizations feel enforced to undertake business-like operations, seeking partners and external funds to enhance the probability of technology transfer and commercialization of their research results. This can lead to the selection of projects tending to overemphasize revenue-generation considerations. This needs a delicate balance to maintain as R&D organization can afford to allow scientists to pursue individual research projects entirely of their own design, at the same time we may not expect highly trained and creative scientists simply to execute projects defined by non-scientific managers or clients.

Keeping in view the complexity of the nature of the R&D activities, sensitivities involved in the management of scientific personnel and needs of the present time (making research relevant to society & economy), management of S&T establishments becomes a highly challenging task for which highly qualified and specially trained managers are required.

In the last few decades, keeping in view the importance of science and technology for human welfare and economic development, all technologically advanced countries and most of the developing countries have constituted various institutions to undertake science and technology policy research, develop S&T indicators, provide analytical reports on different national S&T / R&D issues and programmes and advise the government in order to help it formulate effective science and technology policies and programmes. In Pakistan, the only public sector organization which performs such functions, including science and technology policy research, is the Pakistan Council for Science and Technology (PCST). However, due to its very limited human and financial resources, comparing to its huge mandate, the volume of activities of PCST related to science and technology policy research is very small; and aspects of policy research such as studies of development strategy, S&T management, interdisciplinary studies of natural and social sciences etc. are completely missing. It is worth mentioning here that Institute of Policy and Management - the leading research institute in the field of science and technology policy in China, employs 99 professionals (2012). Only 7 professionals are working in PCST at present.

Targets:

4.1. Establishment of the Pakistan Academy of Science and Technology Management & Planning (PASTMP).

PASTMP will be a body for research and training in science and technology management for the innovation of Pakistan's science and technology management with a view to make Pakistan an innovation-oriented country. It will have the responsibility to construct a high ground of science and technology management research, education, training, develop international linkages in the field, integrate academic resources of science and technology management; and strive to build itself into an institution with unique features.)

4.2. The Academy will provide specialized training for improving management of S&T organizations. Training will be provided at following levels:

- Senior level managers (BPS-20 and above)
- Mid level managers (BPS 18 / 19)
- Young scientists

4.3. Successful completion of this training will be made compulsory to be eligible for the appointment as head of an S&T organization.

GOAL 5

To achieve national development and socio-economic progress by utilizing the talents of women to the full at all levels of scientific and technological education, training and employment.

Pakistan lies among the lowest ranked countries of the world as regards hierarchy of gender development and parity. The global gender gap survey by the World Economic Forum of 135 countries covering more than 90 percent of the world's population placed Pakistan at 134th rank **showing** a widening gap down from 112 in 2006 to 133 in 2011. The survey shows that overall, 88 percent of the countries covered in 2006–2012 improved their performance, while 12 percent widen gaps. Unfortunately Pakistan lies on top of this 12 percent.

Women are about 48.5 % of Pakistan's total population. Despite constituting almost half of the population, women are an underutilized talent. The Labour force participation is only 15.6 percent for women as compared to 49.3 percent for men. The contribution of women is mostly in agriculture sector where they add an estimated 36.8 percent to GNP. The literacy rate of women, especially in scientific and technical education, is far less than men and they do not have access to education and work opportunities. There is a limited pool of female students who can access higher education due to gender disparity in primary and secondary education; poverty; cultural constraints such as early marriages and physical distance to higher education institutes. Although working women have a very positive and transformational impact on society by having fewer children, and by investing more time, money and energies for better nutrition, education and health care of their children, still this ratio is very low not only due to lack of educational opportunities and cultural constraints but mainly due to humble conditions at the workplace. Therefore measures should be taken for dissolution of gender discrimination and bring them into mainstream. It is important to increase women's access to higher scientific and technical education. Traditionally women have dominated health sciences and have neglected the fields of physics, Mathematics, engineering and basic sciences. It is now vital to encourage women to attract them in these non-traditional areas. The need of the time is to identify obstacles that hinder women's participation in the science to ensure maximum enrolment to reduce gender gap.

Targets:

5.1. Literacy rate should be increased by providing equal opportunities for women in education and training.

5.2. Women should be provided free access to all vocational, technical and scientific education.

5.3. Some specific allocations in budget should be made to provide scholarships for women’s education

5.4. Government need to provide an appropriate policy environment which helps women to balance family and professional responsibilities. This support may be for the professional, personal and family needs of women through their education, career development and their employment.

5.5. Policies should focus the areas including a childcare subsidy for working mothers, and accommodating their needs as wives and mothers.

5.6. A program of establishing re-entry scholarships and bridging courses will provide "second chance" opportunities for women to re-enter their chosen profession, to recommence study even after getting married and child bearing.

5.7. Women may be given age relaxation till 40 years in fellowship schemes. This will enable women to come back, work and re-establish themselves in their field. This will save a large potential from getting wasted.

5.8. Age relaxation may be given and seats may be reserved for married women in all universities, especially in the fields of Science and Engineering.

GOAL 6

To raise public awareness and understanding of Science and Technology and promote scientific research.

Public Awareness and Understanding of Science and Technology relates to the attitudes, behaviours, opinions and activities that comprise the relations between the general public as a whole to scientific knowledge and organization. It is a comparatively new approach to the task of exploring the relations and linkages between science, technology and innovation and the public. As we know that science and technology cannot ignore its social role. It is, therefore, important that scientists seek to understand the impact of their work and its applications on society and public opinion. It is equally important that non-experts are able to understand aspects of science and technology which touch their lives.

Public awareness and understanding of science and technology has a prominent impact on the level of governmental support for research, the number of young people devoted to the science and technology careers, and the application and improvement of technology. General public support is very important in order to pursue governments to formulate policies for upgrading S&T status of the country. In developing countries, finding support from politicians, bureaucrats and civil servants has the critical importance as they are the most influential actors in decision making and implementation.

In the developed countries, such as United States, United Kingdom and Japan, national surveys are regularly conducted to study the level of public understanding of science and technology and observe their attitude towards it. Such surveys have also been conducted in some of the developing countries like Australia. However, most of the countries including Pakistan have never conducted these surveys.

Targets:

6.1. Conducting national survey of public awareness and understanding of science and technology.

6.2. Initiation of programmes / activities to raise awareness and understanding of general public.

6.3. Special programmes should be designed and implemented to raise awareness and understanding of politicians and bureaucrats.

6.4. Organization of workshops for promotion of scientific research.

6.5. Support for Science Conferences/ seminars.

6.6. Science Exhibitions/Traveling Expos for school children.

6.7. Coverage of Scientific events through Mass media: Print/Radio/TV.

6.8. Developing of national S&T indicators and provision of S&T Information and literature to researchers, industry and other stakeholders.

4.3. Achieving excellence in emerging sciences and technologies

Focus Areas:

- ⇨ *Nanotechnology*
- ⇨ *Biotechnology*
- ⇨ *Renewable Energies Technologies*
- ⇨ *Materials Science and Lasers & Photonics*

GOAL 7

To set-up a centralized national research facility for developing nanotechnologies and products in accordance with the national needs and to enhance research capacity of existing nanotechnology laboratories.

The essence of this field is to work at the atomic and molecular level to create large structures with fundamental new molecular organization. Nanotechnology is concerned with materials and systems having novel structures and improved physical, chemical and biological properties due to their nano-scale size. The aim of the nano-science and nano-technology is to investigate and exploit these properties by controlling the structures. Maintaining the stability of the interface and integration of nano-structure is another objective. By controlling the feature size, material properties and device functions can be enhanced beyond their existing capabilities. Reduction in dimensions of the structures leads to entities such as carbon nanotubes, quantum wires and dots, nano-particles, thin films, DNA based structures, etc, which have unique properties. Nano-Science and technology is an interdisciplinary area of research and development activity. It has the potential for revolutionizing, the ways and methods, by which materials and products are designed, fabricated, and various devices are manufactured and systems function.

During the past decade nanotechnology has become one of the most important fields of research worldwide. It is one of the most promising technologies offering a wide potential for applications in many industrial and societal sectors. In the last few years application of fundamental discoveries has developed multi-billion dollars product lines. These include giant magneto-resistance multi-layers for computer memory, nanostructured coatings in data storage and photographic industry, nanoparticles for colourants in printing and drug delivery in pharmaceutical field, superlattice confinement effects for optoelectronic devices and lasers, and nanostructured materials such as nanocomposites and nanophase materials.

Nanostructure is critical to design and manufacture of light weight, high strength, thermally stable materials for aerospace applications.

A new field called nano-medicine is emerging which is the science and technology of diagnosing, treating and preventing disease and traumatic injury, relieving pain and preserving human health using nano-structured materials and eventually complex molecular machine systems and nanorobots.

Nanotechnology has the potential to affect the energy efficiency, storage and production. It would be beneficial in controlling the emissions from a wide range of sources. The impact on industrial control, manufacturing and processing will result in energy saving.. Replacement of carbon black in tyres by nanometer size particles of inorganic clays and polymers would lead to wear resistant and more environment friendly tyres.

Further, Nano-Science has vast capability to act as a tool to make advancements in agriculture, biotechnology, electronics, ICT, environment, Textiles and other major sectors.

The worldwide investment on nanotechnology research and development has crossed 20 billion US$ with the USA as major player with the R&D spending worth 7 US$. The other major actor countries in this field include France, UK, Korea, Japan, Canada and China. Recently India and Iran have made significant investment in the field of Nanotechnology.To cater the national needs and to develope the nanotechnology based products having export positional, Pakistan needs to invest heavy amount in R&D in this import area. Followings are the targets set for the promotion of nanotechnology R&D in the country:

Targets:

7.1. Establishment of Pakistan Foundation for Nanotechnology.

7.2. Formulate 05 year and 10 year Plan for Nanotechnology.

7.3. To build international, public/private collaboration and alliances with strategic partners to acquire new technologies.

7.4. To help entrepreneurs set up new companies; and move successful innovations to holistic Technological Clusters.

7.5. Setting up of National Institute of Nanoscience and Nanotechnology with State of Art equipment to develop projects with private - public partnership and help smaller nanotechnology laboratories as a National Level resource.

7.6. To plan for future human resource development qualified with BS/MS/Ph.D degrees to meet future needs.

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

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

GOAL 8

To promote high quality basic and industry-oriented biotechnology research and development.

Biotechnology is a major contributor towards economic growth of developed countries. The biotechnology has traditionally been practiced in Pakistan in different fields of science like agriculture, medicine, energy, environment and industry. Currently the main emphasis of biotechnological research is to address a wide range of possible future uses, which range from improving the nutritional value of food and increasing food supply to controlling or preventing disease in human and animals.

Biotechnology has a very important role to play in the Agriculture sector of Pakistan. Agriculture constitutes the largest sector of our economy. Majority of the population, directly or indirectly, is dependent on this sector. It contributes about 24 percent of Gross Domestic Product (GDP) and accounts for half of employed labour force and is the largest source of foreign exchange earnings. It feeds whole rural and urban population. The various areas in which plant biotechnology and genetic engineering offer great assistance and hope include plant breeding, plant production, plant propagation and preservation of the germplasm. Genetic manipulation offers a ray of hope for both salinity and drought tolerance for the crops. Biotechnology can significantly enhance yields and produce improved crop varieties and animal breeds that will give better performance. Serious efforts on part of the government will be required to integrate the modern recombinant DNA methods in breeding.

Similarly, biotechnology has a number of applications in the health & pharmaceutical sector. Today about 20 percent of all world pharmaceuticals are produced by using biotechnological processes and it has been estimated that by the year 2020, about 50 percent of all pharmaceuticals will be produced in this manner. For example, the insulin used for the treatment of diabetes is produced by biotechnological methods. Genetically modified organisms have also been employed for production of many antibiotics. A number of genes have been identified that cause diseases. This will help immensely in treating a number of diseases in the future.

Biotechnology is also closely linked with the environment. Environmental biotechnology could be used to harness biological process for commercial uses and exploitation. The new technologies offer enormous potential for solving many problems of pollution posed on the environment. Research has shown that microorganisms and their enzymes, whether naturally occurring or genetically engineered can solve major environmental issues. Genetically engineered organisms and their products help in removing heavy metals or organic pollutants, including carcinogens from drinking water and industrial waste water. Similarly bio-fuels offer a huge opportunity to run vehicles with no harmful impact to the environment.

In the country about thirty five (35) institutions are engaged in education and research in biotechnology and genetic engineering. Unfortunately this sector remained ignored and couldn't gain required momentum due to scare resources, inadequate availability of trained manpower and most importantly lack of proper coordination among the institutions. An enhanced government patronage 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. Development of qualified HR in this area is to be actively pursued through HEC. Biotechnology education and research needs interaction and coordination between different disciplines to develop strong base for applied and basic research to promote innovations. The knowledge generated should be transferred from academia to industry to start new SMEs and business enterprises in the fields of pharmaceuticals, agriculture, food, vaccines, chemicals etc.

Targets:

8.1. To develop well trained human resources in the field of biotechnology.

8.2. To promote academia industry linkage for usage of biotechnology, development of new industrial applications to strengthen the economy.

8.3. Formulate a ten year visionary and action plan for the popularization / adaptation of Biotechnological tools.

8.4. Build international, public / private collaboration and alliances with strategic partners to acquire and propagate new technologies.

8.5. Establish a network of interdisciplinary laboratories and innovation incubators to help entrepreneurs to set up new companies and in paving the way for the innovations to holistic 'Technological Clusters'.

8.6. Establish a coordinating cell on 'Biotechnology' and charging it with the task of strengthening the activities of national research program / initiatives in different fields of applied science.

8.7. Enactment of biotechnology related legislations in the light of the draft of 'National Biotechnology & Genetic Engineering Policy & Action Plan' and implementing it with the support of relevant organizations.

8.8. Develop procedure for the PCR based diagnosis of Dengue virus to enhance diagnostic capability and develop indigenous diagnostic kits for tests such as vitamin D.

8.9. To develop transgenics for enhanced yield, stress tolerance, herbicide resistance, balanced nutrition, better water and nutrient utilization capacity.

i. To carry out intensive Research and Development programmes to integrate modern DNA recombinant methods in breeding.

ii. To develop indigenous vaccines against diseases such as hepatitis, malaria, cholera, influenza etc.

iii. To promote research on gene therapy for treatment of genetic diseases.

iv. To effectively use DNA fingerprinting technology in law enforcement and crime detection

v. To fully utilize on Pakistan's rich biodiversity for commercializing the health related natural products and bio-generic drugs

vi. To increase opportunities for bio-processing and bio-engineering

GOAL 9

To expand capacity in Renewable Energy Technologies and increase renewable energy share in the total energy mix of the country by promoting affordable Renewable Energy Technologies.

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 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 Pakistan 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.

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.

Pakistan is blessed with the abundance of renewable energy potential, but so far, this has not been harnessed. The following Table provides an indicative summary of Pakistan's alternate or renewable energy potential:

Resource	Potential
Wind	Pakistan has an estimated wind power potential of 346,000 MW; out of which around 60,000 - 70,000 MW is technically exploitable. The Wind Map of Pakistan indicates major wind corridors in the Southern parts of Sindh, North Western parts of the Balochistan, Central parts of Khyber Pakhtunkhwa and Azad Jammu and Kashmir, with several isolated wind corridors in Central and Western Punjab, Southern Balochistan and Gilgit Baltistan areas.
Small Hydro	As per the preliminary studies and available data, the potential for small hydro is around 4,500 MW in Pakistan.
Solar: Photovoltaic (PV) and Thermal	Pakistan is fortunately blessed with solar potential of more than 5 - 6 kWH/m2/day of irradiation in many areas. The potential is feasible for both Solar PV and Solar Thermal application. The area with highest solar potential is the province of Balochistan followed by Eastern Sindh and Southern Punjab, promising technically / financially viable solar energy projects.
Biomass: Bagasse, Rice Husk, Straw, Dung, Municipal Solid Waste, etc.	Pakistan's agricultural and livestock sector produces large amounts of biomass in the form of crop residues and animal waste, such as bagasse, rice husk, and dung, much of which is currently collected and thus used outside the commercial economy as unprocessed fuel for cooking and household heating. In addition, the municipal solid waste produced by a large urban population is presently openly dumped, which could instead be disposed of in proper landfills or incinerated to produce useable methane gas or electricity. This sector has an estimated potential of generating 4,000 MW of power.
Geothermal	There are several sites identified in different parts of the country having exploitable geothermal potential [with different ranges of temperature and pressure underneath earth surface]. The geothermal heat available at these sites can be thus used for power generation as well as internal heating and cooling purposes. This sector has an estimated

	potential of generating 2,000 MW of power.
Ocean	Pakistan is blessed with 1,046 km long coastal belt. There are several sites within this belt which can be exploited for the power generation. However, exact potential of generating power from the ocean is yet to be exploited.
Biofuels	Pakistan being agricultural country is having huge prospects for energy plantation. Around 34 million hectares of marginal land is available in different parts of the country that is best suited for this purpose. This sector has a potential to produce 50 million tones of biofuels per annum.

Fuel Cells:

Another promising renewable energy technology constitutes 'Fuel Cells'. Fuel cell and hydrogen technology are among the key innovations that offer prospects for a low carbon economy. Fuel cells produce electricity, heat and water from an input of hydrogen fuel into a cell constructed of an anode, an electrolyte, and a cathode. They are different to batteries which are closed thermodynamic systems, whereas fuel cells are open thermodynamic systems with fuel flow in and output flows. The essential technology is that the hydrogen fuel is split into protons and electrons by the platinum catalysed anode. The electrolyte only allows the protons to flow through it, so the electrons convert to an electric current at the nickel anode. When the protons reach the cathode, they react with oxygen to produce water and heat.

The deployment of 'Fuel Cells' offers promise for a truly sustainable economic development with minimal environmental consequences. The uses include those at homes, in grocery stores, warehouses, commercial and industrial buildings etc. There are three main markets for fuel cell technology: stationary power, transportation power, and portable power. Stationary power includes any application in which the fuel cells are operated at a fixed location, either for primary or for backup power, or for combined heat and power. Transportation applications include motive power for cars, buses and other fuel cell passenger vehicles, specialty vehicles, materials handling vehicles (e.g. forklifts) and auxiliary power units for highway and off-road vehicles. Portable power applications use fuel cells that are not permanently installed at a location or fuel cells installed in a portable device.

The Fuel cells are widely regarded as the key means for converting hydrogen to energy and, as such, have a clear enabling role in realizing aspirations for a hydrogen economy. The ‘hydrogen economy’ concept covers a range of ideas where hydrogen plays a major role in clean energy systems of the future. The ability to operate fuel cells with fuels ranging from fossil fuels, through biomass-based fuels (e.g. landfill gas) to renewable sources means that they could support all steps in the transition to a hydrogen economy based predominantly on renewable energy sources.

There is practically no limit on deployment of Fuel Cells on technical grounds. The use of Alkaline Fuel Cells (AFC), Phosphoric Acid Fuel Cells (PAFC), Proton Exchange Member Cells/Polymer Electrolyte Fuel Cells (PEM),Solid Oxide Fuel Cells (SOFC), Molten Carbonate Fuel Cells (MCFC), range in efficiency between 55-60% and are increasingly been used worldwide in as diverse applications as space programs, power generation, transport, etc.

Targets:

9.1. Establishment of national Centre for ‘Hydrogen and Fuel Cell’.

9.2. 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.

9.3. Development of pilot projects and their large-scale dissemination based on existing technologies such as solar water heaters, biogas plants, photovoltaic etc.

9.4. Development and commercialization of cost effective solar energy products.

9.5. Designing and installation of ultra low head microhydel plants.

9.6. Performance evaluation of commercial biogas plants available in Pakistan.

9.7. Production of high quality solar panels.

9.8. Technology transfer and provision of consultancy services to private and public sector regarding renewable energy technologies.

9.9. Immediate focus on wind turbine technology.

9.10. Promotion of affordable Renewable Energy Technologies.

9.11. Fostering active collaboration between NUST and PCRET for research projects in Renewable Energy.

GOAL 10

To establish specialized institutes in interdisciplinary emerging areas having applications in multiple fields.

Materials Science and Engineering

Materials science and engineering is a multidisciplinary subject drawing on all branches of science and combining them with manufacturing technology and design to solve engineering problems. The field of "materials" encompasses concepts in many diverse fields ranging from chemistry, physics, and optics to mechanical, electrical, and chemical engineering. Rapid advances in technology have dramatically increased the importance of materials science and engineering to society. In today's world, materials science underpins every product and process on which our modern society depends.

The underlying importance of materials science to economy of a country is illustrated by the wide range of industries which it underpins, from electronics to construction, transport to healthcare; all are reliant on a fundamental understanding of the structure, properties, and performance of materials. Presently, the global materials industry is worth an estimated US $600 billion.

Materials researches are of crucial importance to emerging technologies, the most significant of these being the ability to manipulate, design, and create materials on the atomic scale – through nanotechnology. This area of technology has the potential to transform nearly every aspect of everyday life, opening up new capabilities and markets, making improvements to the quality of life.

New materials are the sparks that fire technological revolutions. Sixty years ago nylon revolutionized the fashion industry; 30 years ago the silicon chip revolutionized information technology; ten years ago biomedical materials began a revolution in healthcare. New horizons are extending at both ends of the size spectrum: from microscopic devices performing surgery at the end of a cardiologist's catheter, to huge lightweight space stations and giant 800-seat passenger aircraft.

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. 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.

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 centres 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.

Lasers & Photonics

Photonics, (the science of the photon) has been identified as one of the most prominent cutting-edge fields in science and technology for the 21st century. Photonics is the technology of generating and harnessing light and other forms of radiant energy whose quantum unit is the photon. Photonics involves cutting-edge uses of lasers, optics, fiber-optics, and electro-optical devices in numerous and diverse fields of technology which is eveident from the following list of “Photonics-enabled fields:

- **Aerospace technology** - Uses LiDAR (laser RADAR systems) and laser altimeters, imaging systems for test and analysis of aircraft, holographic heads-up displays, and optical pattern recognition systems for navigation
- **Agriculture** - Uses satellite remote sensing to detect large-scale crop effects, scanning technology and infrared imaging to monitor food production and quality, and sensor systems for planting and irrigation
- **Biomedicine** - Uses lasers for surgery, therapies such as photodynamic therapy, and in situ keratomileusis (LASIK) procedures; uses testing and analysis devices such as non-invasive glucose monitors
- **Construction** - Includes scanning site topography, laser bar-code readers to inventory materials, laser distance measuring and alignment, and three-dimensional analysis to track the progress of construction

- **Engineering, microtechnology, and nanotechnology** - Uses lasers in the manufacture of electrical devices, motors, engines, semiconductor chips, circuits, and computers; via photolithography, photonics is central to mems production
- **Environmental technology** - Uses ultraviolet Doppler optical absorption spectroscopy (UV-DOAS) to monitor air quality; uses fast Fourier transform analysis to monitor particulate matter in effluents released from stacks
- **Geographic information systems and global positioning** - Uses optics and photonics in imaging and image processing to refine atmospheric and space-based images
- **Information technology** - Uses optics for data storage, ultrafast data switching, and (especially) transmission of data across fiber-optic networks
- **Chemical technology** - Relies on molecular optical spectroscopy for analysis and on ultra-short laser pulses to induce fluorescence; chemical vapor deposition and plasma etching support photonics thin film applications
- **Transportation** - Uses optics for monitoring exhaust emissions to ensure the integrity of shipping containers arriving from foreign ports, and navigation with ring laser gyroscopes
- **Homeland security** - DNA scanning, laser forensics, retinal scanning, identification of dangerous substances, optical surveillance
- **Manufacturing** - Laser welding, drilling, and cutting; precision measurements

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.

Targets:

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

10.2. Setting up of an Institute for Lasers and Photonics as part of a National Programme on Lasers and Photonics.

4.4. Optimal utilization of established technologies

Focus Areas:

- ⇨ *Information Communication Technologies (ICTs)*
- ⇨ *Space Technology*
- ⇨ *Ocean and Mineral Resources*

GOAL 11

To extend support for the deployment of ICT services in Government Departments, Educational Institutions and Commercial Enterprises.

Information & Communication Technologies (ICTs) have a demonstrably positive effect on income growth in both developing and developed countries. The last 10 years or so have been a blooming business area for the Information ICT Sector in Pakistan that has attracted investment of billions of rupees of tax payers' money. The main thrust of funding came from the ICT R&D Fund which facilitated hundreds of ICT research projects in the Public/Private Sector Universities/ Organizations, primarily in the urban areas. Pakistan is perhaps, one of the leading developing countries which have an outreach of more than 70% of its rural areas in terms of the ICT coverage. This is the time now to launch horizontal innovation programmes linking our rural and urban areas through Public/Private Partnerships in the all-important Education, Health, Agriculture and Community Development along with Women Entrepreneurship Sectors of our Economy (ECO). This would not only bring schemes of new wealth generation but also will result in creation of millions of new job opportunities', even at the village level thus minimizing the rural-urban divide. The Innovation Economies have played a major role in countries like China, Brazil, India, Singapore, Malaysia, Turkey, South Africa, Argentina etc., in terms of their GDP growth. In Pakistan, the ICT Sector is contributing only 1% of our GDP but has a potential of taking it to 5% of our economy, provided we adopt out-of-box strategies for the next five years or so. The Government of Pakistan has already made major investments in this rapidly expanding sector, but the real need of time is professional management by innovation managers to leverage the existing ICT Infra-structure to spin-off ICT Start-Up Companies in the rural as well as urban areas of Pakistan. The horizontal growth of ICT companies would initially jump start our Innovation Economy covering the length and breadth of our country. Cyber Entrepreneurship Programmes especially tuned for women ICT professionals to work and earn from home would be adopted in order to facilitate women entrepreneurship. After this massive beginning we may like to adopt the Business Acceleration Programme (BAP) in picking up some of the dynamic companies for their Vertical Growth to compete at the global innovation market.

In Pakistan, ICT sector saw a prominent growth during the decade of 2000. Pakistani ICT and Information Technology Enabled Service (ITES) companies grew at the rate of 30-40% during that period. However, Pakistan has moved down to the position of 105 (out of 144 countries) on Network Readiness Index(NRI), according to the Global Information Technology Report (2013) released by the World Economic Forum (WEF). On the other hand the tele-density has increased from 4.3% in 2002-2003 to 73.5% in May 2013 with 125.01 million cellular subscribers of 5 GSM Operators (Mobilink, Ufone, Telenor, Warid and Zong); 2.98 million fixed lines subscribers of PTCL, NTC, Brain Limited, World Call and Nayatel; 2.9 million Wireless Local Loop subscribers; and 2.6 million broadband subscribers (Pakistan Telecommunication Authority - PTA). The poor ranking of Pakistan on NRI is, inter alia, due to extremely low 'Usage Sub-index' (118th position among 144 countries). 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 (2012) and total IT/ITES exports have been valued at USD 1.4 billion (2007).

The CIIT and NUST are paying major role in imparting quality education at under-graduate as well as at postgraduate level in almost all disciplines related to ICT. All the organizations of this Ministry are working to digitalised documents for easy access to public. The CIIT and NUST have already established state of the art on-line system. At NUST all the students affairs matters are dealt online.

HEC has already established six ORICs' (Office of Research, Innovation & Commercialization) in the leading public sector universities. These could be utilized initially to establish ICT Innovation Centres to incubate ICT companies in the private sector as a pilot project. The network of these Innovation Centres could then be expanded to cover each district in the form of District Innovation Centres (DICs'). A well-defined three tier National Innovation Architecture in the form of DIC, PIC (Provincial Innovation Centres) and NIC (National Innovation Centre) in the Capital, Islamabad be adopted for creating harmony in the growth of our Innovation Economy. The Bayh-Dole Act of USA which came in 1980 was instrumental in jump starting their innovation programmes through the public sector universities/organizations by providing the legal cover for their inventors/innovators; need to be studied thoroughly to adopt our legislation on innovation, if required, in due process.

Targets:

11.1. Make ORICs effective innovation centres in the universities under the Ministry of Science and Technology.

11.2. Provision of ICT training to Women Professionals to work and earn from home and contribute towards women empowerment.

11.3. Facilitating on-going projects in e-Education, e-Health, e-Agriculture and pursuing other prioritized e-government projects.

11.4. Promoting three tier Innovation linkage between DIC, PIC and NIC to have an all-inclusive Innovation Programme for the country.

11.5. Development of quality human resources in the field of ICT.

11.6. Encouraging entrepreneurial activities in ICT-based businesses.

GOAL 12

To develop and promote the indigenous space technology applications in the fields of education, communications, remote sensing, early flood warning systems and disaster management etc.

Space technology is the harbinger of prosperity, self-reliance, strategic dominance and economic vitality. It is a catalyst that infuses technological vigour through innovative solutions. Most of the developed and developing countries are in pursuit of either becoming space-faring nations or further strengthening their position, to reap the short term benefits and achieve long term goals of space innovations & applications. The benefits associated with the peaceful use of space have completely outstripped the tunnel vision of the cold war era.

There is a realization that no nation can afford to go alone 'all the way' to achieve success in Space Technology in an economically viable paradigm. For example, USA discontinued their advanced Space Shuttle program owing to huge operational cost, and now uses Russia's launcher to send astronauts to work on space station.

The new paradigm dictates need for space technology infrastructure, collaboration, exchange of ideas, and continual interaction. International space station is an excellent example of this new paradigm; where United States, Russia, European Union, Canada, and Japan have joined hands to develop space technology and find solutions to terrestrial and everyday societal challenges.

Space technology is evident in all aspects of societal needs that includes worldwide connectivity through converged networks, serving both urban and remote/ hard to reach areas, advanced positioning systems, sophisticated navigation, measuring crops productivity, accurate urban planning, water management, fire management, weather predictions, flood warnings, forest management, geological studies, maritime services, resource monitoring, disaster management, surveillance, search and rescue, pharmaceutical products, environment monitoring, robotics, imaging, telemedicine, tele-education, advanced materials, energy efficient devices, hybrid engines, fuel cells etc.

Initial pace of space technology development, subsequent to the launch of Sputnik in 1957, was slow and scope of payloads was very limited. However as the technology started to mature and benefits became more evident; the thrust to develop new, smaller and efficient space systems offering array of services gathered pace. So much so that now space debris is becoming a risk for new satellites, particularly in the low Earth orbit. A large segment of these small low earth debris consist of low cost technology demonstration satellites for launching bigger satellites or satellite constellations or satellite swarms, in the future.

Current State of the Space Systems/ Satellite Industry

The 2012 revenue from satellite industry stands at about US $ 190 Billion, a 5% increase from last year. The industry consists of the following four segments:

1. **Satellite Services Sector**
   Revenues of US113.5 Billion in the year 2012
2. **Satellite Ground Equipment**
   Revenues of US $ 54.8 Billion in 2012
3. **Satellite Manufacturers**
   Revenues of US $ 14.6 Billion in 2012
4. **Satellite Launch Industry**
   Revenues of US $ 2.2 Billion in 2012

   (The bulk of the ground equipment revenue coming from satellite TV, satellite, broadband, mobile satellite terminals, and GPS devices)

In terms of revenues, satellite services and satellite ground equipment earn most of the revenue, followed by Satellite manufacturing and satellite launch industry. The last two segments are considered as strategic assets. Overall space industry is a commercially viable business, if all its segments are properly focused in a balanced manner.

A number of developing countries embarked on space technology quite early, in 1970s-80s, and have spent significantly large funds on infrastructure, human capital and space programs. For example, India is spending about US$ 650M per year on its "Indian Space Research Organization", employing a work force of over 16000 personnel.

In Pakistan, space technology was not given due importance and hence inadequate funding towards space programs. As a result, 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 Institute of Space Technology (IST) in 2002 was a major step toward self reliance in space technology and human capital development. The funding of both SUPARCO and IST must be enhanced to preserve critical national interests.

Targets:

12.1. To develop a national level consensus, at the highest forum, for space programs' funding compatible with the expected outcome.

12.2. Align the pace of space technology endeavours with other countries.

12.3. Government may consider ten years tax break for space segment related ground equipment manufactured or software produced in Pakistan. It will give incentives to established companies to set up their plants in Pakistan, and local entrepreneurs to make ground equipment in Pakistan.

12.4. To build satellite development centre infrastructure at IST; having facilities to develop, test and qualify satellites up to 100 Kg. The centre will work on the development of the satellite bus as well as payload designs. It will be a hub for all national universities to participate in satellite and payloads design and development. The centre will also attract international researchers and collaborations with premier international space technology research institutes.

12.5. To build centre of excellence at IST for design and development of satellite ground equipment.

12.6. To build IST Research park and invite national and international organizations to get space at nominal rates.

12.7. To formulate long strategy for building a fleet of geostationary satellites with advanced payloads, such as utilization of Ka frequency band, regenerative transponders and co-location, for creating hot spots.

12.8. To develop space launch vehicles for LEO and GSO satellites.

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

GOAL 13

Sustainable exploitation of oceanic resources and sea related minerals for economic development.

Ocean Resources

The Pakistan coast is about 990 km long extending from the Indian border on the east to the Iranian border in the west. The Exclusive Economic Zone (EEZ) of Pakistan is about 240,000 sq. km with an additional continental shelf area of about 50,000 sq. km. As such, the total maritime zone of Pakistan is over 30% of the land area. This region is characterized by distinctive oceanic phenomena, that produces rich fisheries, mineral, and hydrocarbon resource.

A total of 370 kilometres (km) of coastline extends along the province of Sindh between the Indian border along Sir Creek on the east to Hub River on the west. Mangrove forests are a major feature of the Sindh coast. A combination of the subtropical environment and the riverine flow into the Indus delta has resulted in a highly productive coastal zone of significant biodiversity and economic value. These deltaic networks of creeks are a major breeding area for commercially important coastal fisheries that include shrimps and crabs. About half of the fish exported from Pakistan is netted on the Sindh coast.

Pakistan coastal area is not only rich in living resources but it is also characterized by distinctive oceanic phenomena that could produce abundant mineral, renewable energy and hydrocarbon resource. According to a preliminary survey conducted by the National Institute of Oceanography, it is estimated that about 1100 MW power can be produced from the Indus Deltaic Creek areas. NIO is planning to conduct detail research for reassessing the potential of tidal energy by utilizing latest survey and modelling tools and with the technical assistance of Second Institute of Oceanography, China under the MoU signed between Ministry of Science & Technology, Pakistan and State Oceanic Administration, China. Recent estimates indicate that out of the total marine resource production for Pakistan, 71% is derived from Sindh. However, coastal communities are one of the poorest communities in Pakistan and their livelihood resources are under constant threat of depletion. About 90% of the households in the coastal communities rely on fishing and other fisheries related activities

Mineral Potential

The origin and nature of the geological features and processes along the coast suggest that the Pakistan marine geological environment is favourable for the formation of mineral resources. Continental margin and sea floor of the northern Arabian Sea possesses all the important geological features which create bright prospects for non living resources. The coastal areas and continental margin of the Arabian Sea contain a wide variety of mineral deposits of zirconium, rutile and limonite. Deltaic environments are especially favourable for oil, gas, coal and heavy mineral deposits. During the past few years exploration work has been significantly intensified. NIO has taken up a project with the Chinese assistance under which the existing 2D multi-channel seismic data acquired from the Arabian Sea by difference academic and oil & gas industry would be reprocessed on latest softwares to determine the resource potential of offshore areas of Pakistan. This study would also assist in estimating the reserves of gas hydrates along the Makran coast.

Pakistan has enormous potential and opportunities to exploit the ocean resources and mineral. However, this sector requires massive investments to develop our national capabilities to take the benefit from ocean related resources. The following targets are proposed in this regard:

Targets:

13.1. Review of Pakistan's Case by the sub-commission of the Commission on the Limits of the Continental Shelf regarding extension of Continental Shelf.

13.2. Geological Studies of Gas Hydrates deposits along the Makran Margin.

13.3. Establishment of National Central Marine Research Laboratory.

13.4. Survey & exploration of mineral deposits in the coastal zone and near shore region of Balochistan.

13.5. Strengthening Ocean Research through Collaboration between China and Pakistan under MoU on development of Marine Science.

13.6. Survey of land subsidence in Indus Deltaic area near Karachi with collaboration of SIO, China.

13.7. Oceanographic studies in the Arabian Sea onboard Chinese Research Vessel.

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

13.9. Mapping of oceanic resources including both living and non-living resources in the maritime Exclusive Economic Zone as well as under seabed for assessing the potential of their utilization.

13.10. Exploitation of tidal energy potential and sea-based minerals such as gas hydrates.

13.11. Establishment of Marine Remote Sensing Facility for strengthening ocean research.

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

4.5. Technology and innovation support to industry for enhancing exports

Focus Areas:

- ⇨ *MSTQ System*
- ⇨ *Innovation and Technology Development*
- ⇨ *Electronics*
- ⇨ *Engineering*

GOAL 14

To make Pakistani products competitive in the international markets through a robust system of quality control, testing and certification.

In a free-market world economy, the secret of success in sales of products lies in brand names, which serve the purpose of satisfying consumer expectations in terms of quality of materials, design and workmanship. The countries with unsatisfactory systems of quality control, Intellectual Property Rights (IPR) adherence, and implementation of ISO and other relevant international standards, usually end up with minimal market share. It is of paramount importance, therefore, to radically improve the Metrology, Standards, Testing and Quality Control (MSTQ) system of the country in order to fulfil the promise of paradigm shift in R&D in emerging technologies and its strategic exploration through commercialization opportunities to create new companies, new solutions and news jobs.

In Pakistan, following organizations deal with different aspects of MSTQ:

Pakistan Standards & Quality Control Authority (PSQCA)

PSQCA is the national body for the formulation and promulgation of Pakistan Standards which is a member of International Organization for Standardization (ISO), International Electro-technical Commission (IEC), and International Organization of Legal Metrology (OIML). PSQCA advises the Government on standardization policies, programmes and activities to promote industrial efficiency and development, as well as for consumer protection.

National Physical & Standards Laboratory (NPSL)

NPSL is the national metrology institute of Pakistan which maintains primary standards of measurement and materials with international traceability, that gives traceability of measurement to other laboratories. Thus NPSL by maintaining the national standards of measurements and materials acts as the focal a point for all calibration / standardization and testing needs of the country, and as CIPM MRA is the only certified link to the international measurement system.

Pakistan National Accreditation Council (PNAC)

PNAC as the National Accreditation Body has the mandate to accredit conformity assessment bodies like Testing and Calibration Laboratories, Medical Laboratories, Certification Bodies, Inspection Bodies and Halal Certification Bodies. PNAC has secured, the Mutual Recognition Arrangement (MRA) signatory status in the year 2009 with International Laboratory Accreditation Cooperation (ILAC) & Asia Pacific Laboratory Accreditation Cooperation (APLAC) as well as Multilateral Recognition Arrangement (MLA) in this year with International Accreditation Forum (IAF) and Pacific Accreditation Cooperation (PAC).

Pakistan Council for Scientific & Industrial Research (PCSIR)

PCSIR is the organization of Ministry of Science & Technology that has a laboratories complex in all provincial capitals and along with other private labs of Pakistan is providing testing facilities in different scopes.

The global market competitiveness urges us to recognize 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. The participation of both public and private sectors in standardization activities is essential for enhancing Pakistan's competitiveness in international trade. Whereas, it is necessary to strengthen the national standardization infrastructure, an intensive effort to create awareness in R&D organizations / universities / general public about the role of standardization in economic growth would be required. The system needs to be revamped to remove remaining contradictions and weaknesses for making it more effective.

Targets:

14.1. Setting up NPSL as the National Metrology Organization as a separate entity, independent of PCSIR through an act of Parliament.

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

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

14.4. Increasing the number of mandatory standards manifold from its current figure of 92 and enforcement of these standards on imported goods also to prevent flooding of sub-standard goods of foreign origin in local markets.

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

14.6. Involving the provincial set-ups in the enforcement of Pakistan Standards and strengthening them adequately for this purpose.

14.7. 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.

14.8. Induction of Standardization related subjects in the academia/universities through Higher Education Commission.

14.9. Establishment of textile testing house at Karachi to check the AZO dyes and ECO testing in order to boost the export potential of the country.

14.10. Establishment of Calibration Laboratory traceable with NPSL and accreditation from PNAC.

14.11. Registration of Inspection Agencies as per section 8(xxii) of PSQCA Act.

14.12. Establishment of Chemical/Physical laboratory at Quetta.

14.13. Establishment of mobile testing labs for Balochistan, Northern Punjab, Southern Punjab and Khyber Pakhtunkhwa.

14.14. Promotion of quality culture through Voluntary Certification Scheme and induction of 20 industrial products in VCS.

14.15. Establishment of Knowledge Centre at PSQCA Complex Karachi.

14.16. Establishment of National Mirror Committee in parallel of ISO/COPOLCO.

14.17. To improve and enlarge the scope of MSTQ and IPR system in the country.

14.18. Create capacities in PSQCA, PNAC, NPSL etc. to promote quality culture for trade enhancement.

14.19. Development of Pakistan Standards for energy efficiency, alternative energy, bio-technology, textiles and leather products (130 standards).

14.20. Ensuring the uniform application of standards throughout the country by harmonizing federal and provincial laws.

GOAL 15

To create an environment conducive for innovation and technology development.

Technological innovation – backed up by scientific research – has always constituted a driving force of transformation for organizations, institutions and the society, at large. The co-evolution of technology and institutions is manifested in the changes brought out in production processes, creation and development of new lines of business, increasing the market share of products, exploring new markets, and spurring new institutional modes of social interaction, both within the country and across border. The organizational milieu and institutional set-up in turn equally well influence the learning, adaptation and competence building ~ building blocks of innovation.

Technology is also regarded as a process, a social mechanism which becomes inclusive overtime and brings individuals together, or drives them away. It creates special interest groups, impacts the natural or developed environment in which individuals live, and alter the cultural patterns, the way we think and act, and the way we see the world and understand it – whether we have taken ownership of these technologies or are marginalized by their deployment. Thus, the emergence, dissemination, transformation, diffusion (and even disappearance of technology to give way to the one with better features / economics) – are actual promoters for change. They are fundamental constituents of what will outline the present and determine the future.

Today, technological innovation plays a considerable role in incentivizing and facilitating the knowledge exchanges and in improving the living standards. It determines to a large extent the bargaining power of nations – thus influencing the flows of knowledge, technology, products, services, and more importantly, the capital across geographical borders. Infact, the world is no longer divided into self - proclaimed hegemonic blocks, be they have a political identity to allow economic interests to override and surmount geographic barriers, and other conflicts (cultural, historical, religious, etc.) that may be there to allow groupings and alignment with countries with similar or interests complementing each other.

In the future, developing and emerging countries, given their demographic and geographical weight as well as the potential for growth (that some of them have unleashed), will face major challenges that the humankind is currently grappling with, and are likely to do so much more effectively than the old industrialized powers by offering the most befitting responses to solve them – provided they have the necessary resources and capacity to do so. In this light, generally true for developing countries, scientific and technological breakthroughs would act as harbinger for creating newer economic opportunities.

Science, Technology & Innovation in Pakistan

Over the past several decades, Pakistan has faced and tried to overcome numerous challenges primarily arising from conflicts / natural disasters. Each successive government had to adopt per se strategies compelled by dictates of the day. The long - term development and progress has thus been compromised in the process. Yet, as a consequence of reactive nature of policy formulation and implementation, the government institutions are conditioned to think in terms of ‘projects’ instead of ‘growth strategies’. Today, Pakistan confronts a new round of challenges and urgent demands. It is precisely at this moment – in the aftermath of devastating floods recurring almost each year for the past 4 years and a burgeoning expenditure being spent on national security – the role of science, technology and innovation has become as important as it had never been before. The politics of reactive policies and dependence on external aid have not helped Pakistan or for that matter any other country. A strong resolve in creating conducive environment for encouraging / promoting innovation and technological development is thus the only respectable way to prosperity and self - reliance.

The National Innovation System (NIS) in Pakistan is still not fully developed. In the formal and narrower context, components of an NIS include but are not limited to; universities, education / training / R&D institutions, standard setting bodies, industry structure encouraging competition, policies promoting intra and international technology transfer, availability of risk capital, and so forth. A fragmented NIS tends to impede the country’s indigenous technological capability (ITC). NIS plays a crucial role in countries’ efforts to catch up with the technological advances and impact upon a country’s economic performance.

The ability of nations to develop a true appetite for the knowledge depends on their ability to search, access and absorb knowledge developed elsewhere and their capability to assimilate and adapt it to suit local conditions. Research and development (R&D) expenditure, both public and private, is needed not only for generation of the new knowledge, but also for absorption, adaptation and diffusion of imported knowledge and technology. A concerted effort on R&D influences upon learning, adaptation and building competitiveness – ingredients for spurring economic growth. While the public R&D expenditure is significant for supporting university research in both basic and applied fields, it is private sector (business) R&D expenditure which is critical for learning and building absorptive capacity in order to bring about a major economic change. The experience of developed countries entail, that it is the increase in share of private sector R&D which brings market returns.

Science, Technology & Innovation Statistics of Pakistan

ST&I Indicators	Value
Research & Development Expenditure (% of GDP)	0.56
Number of R&D Organizations	85
Number of Higher Education Institutions (Public & Private)	132
Researchers in R&D (per million people)	162
Technicians in R&D (per million people)	64
Number of Scientific and Technical Publications (2012)	9,240
Annual Research Patent Applications (Residents in Pakistan)	92
Global Competitiveness Index Ranking (Out of 144 economies)	124
Global Innovation Ranking (Out of 144 economies)	75
High - Technology Exports (in million US$) (High - Technology Exports: % of Manufactured Exports)	316 2.0

Source(s): World Bank; Pakistan Council for Science and Technology; Higher Education Commission, Govt. of Pakistan; Scopus Database; SJR International Science Ranking; Ministry of Science and Technology, Govt. of Pakistan; The Global Competitiveness Report, World Economic Forum.

Pakistan has a very limited R&D base, consequence being a low level of innovative capabilities by any world standards like filing of patents, commercialization of locally developed technology or gainful deployment of the imported technology. The present R&D expenditure in Pakistan is 0.67 % of the GDP. The comparable figures are South Korea: 3.74, Japan: 3.67, United States: 2.7, Germany: 2.3, China: 1.97, India: 0.9, Turkey: 0.7 (World Bank, 2012). In order for Pakistan to move towards the apex of R&D and innovation, it is necessary for it to develop its indigenous ITCs. However, given the market imperfections and other national priorities that are there, a phenomenal increase neither seems possible nor imperative unless the capacity of the S&T system is built to conceive and take up R&D projects. The development of ITC for innovation at both the national and firm level necessitates that a workable policy framework be first put in place. Focus on technologies which have a direct bearing on the national requirements like combatting water scarcity, energy and food supply, etc. and certain emerging technologies like new materials, nano and bio technology, etc. is essential. Moreover, it is important to note that such interventions would directly contribute to strengthening the NIS.

Need for Innovation Led Technology Development in Pakistan

Pakistan's R&D system is currently oriented towards supply side, while very little interaction is made with industry; the latter though is ultimate user of the products or processes developed in the R&D organizations / research universities. There is negligible R&D activity in the industrial sector, a complete contrast with the industrialized countries where the industry is considered a major contributor to the expenditure on R&D. Contract R&D is also limited due to absence of incentives and unavailability of bridging institutions such as technology incubators, risk capital, technology brokers, technology parks and so forth. Legal instruments similar to US Bayh - Dole Act 1982 are completely missing. There is an urgent need to re - orient the public sector R&D organizations / research universities to incentivize them to take up demand - driven research in collaboration with industry. In this regard, the Government - Industry partnership programmes should be launched where researchers will provide technical assistance to private sector firms and companies. Initially, it will be necessary for scientists to demonstrate that they are in a position to resolve technical and technological problems of the industry within a reasonable timeframe and at a relatively much lower cost. Once mutual trust is established, the industry would be willing to approach R&D organizations / research universities of the country rather than looking towards the foreign sources of technology or technology adaptation issues. The Government can enhance linkage between public R&D organizations, research universities and industry by directly supporting industry activities that are related to innovation i.e. learning, adaptation and competence building, facilitating commercialization of technology, providing mobility to the qualified personnel across R&D institutions, and sharing of technical facilities possessed by these entities. The focus of research should be diverted towards small number of strategic areas that have a bearing on the national socio - economic needs, are futuristic in character and / or yield higher economic returns. Increasing inter - institutional coordination and competition as well as providing a steady flow of qualified and skilled workforce are basic building blocks of building capability and increasing competitiveness of industrial products in international markets. The reverse - engineering efforts, where feasible, should be encouraged.

In most OECD countries, the share of public R&D expenditure has declined over the preceding decades but business R&D spending is rising. Likewise, business R&D accounts for nearly 70% of total R&D spending in China, the figure stands at 68% in the United States, 75% in Korea and Japan, and 70% in Germany. This figure stands at a paltry 10% in Pakistan. Even worse it is stagnant for several years. In comparison, the share of business R&D as a percentage of total spending on R&D is rising in India (World Bank, 2012; Ministry of Science & Technology, Govt. of India). Trans National Companies (TNCs) are an important source of business R&D for the innovative firms in developing countries, as they seek alliances with the national or regional firms. The primary incentive is to gain access to the local techniques and knowledge, exploit R&D carried out in such companies, build insight for the better technology management and marketing capabilities, etc. India and China are leading recipients of R&D from TNCs. In Pakistan, the policy incentives may be introduced to seek effective technology transfer, and encourage large local companies especially those in the public sector to establish / strengthen their R&D facilities. Initiation of R&D by the public sector entities though not a replacement of the private investment in R&D still creates a demonstration effect for the private sector large enterprises.

Producing corps of knowledge workers, particularly scientists, engineers, and skilled workforce is unarguably one of the most important pre - requisites for building technological capability. Without such corps of trained personnel, it is not possible to institute a culture amenable to learning, systemic R&D and innovation. Ensuring a sustained supply of talented youth poses both a challenge but an opportunity as well, for a country like Pakistan which is blessed with enormous population base and highly talented youth which constitute nearly 54% of the total population comprising some 180 million people. This offers an enormous demographic dividend ready to be realized, provided we can first invest in it. Moving this abjectly resource - less poor workforce from low productivity agricultural and industrial practices to rigours of knowledge economy already seems over - delayed. The glorious past of the Islamic intellect dormant for some 1,000 years needs recreation through diverting the first - rate human resource to careers in science and research. Hence, technical and tertiary education could become the medium of moving Pakistan into the 21st century. Every effort should be made to devise special incentive mechanisms, so as to stimulate state-of-the-art research in the universities and develop leaders in science and engineering.

The international network of researchers is another considerable source of knowledge transfer in developing countries. The Taiwan's computer industry and India's IT industry have greatly benefitted by their diaspora. Diaspora networks of

Pakistan are not functional to build and maintain liaison with their countrymen. Therefore, reliance can still be made on the global pool of R&D manpower in order to meet the immediate needs of the industry, while ensuring that the 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 (by providing them necessary incentives) as their knowledge and international linkages are likely to benefit and boast nascent R&D sector in Pakistan.

The low participation of women in the ST&I activities has been a long standing, international phenomenon, even in the countries generally considered as modern, progressive and socially emancipated. This is generally attributed to two broad albeit closely inter - related issues: first, women's perception of their role and function in society, and second, society's expectation of their contribution. Women's involvement in the ST&I encounters a societal bias with regards to their choice of academic disciplines and even with regards to their assuming of professional responsibility. Women are divided between two spheres: upkeep of the home and family, and fulfilment of job responsibilities. Family commitments, either as women's choice or as a result of cultural enforcement, have impaired women's capacity (in most of the cases) to realize their potential, and have put them at a disadvantage in many ST&I related jobs. There is a need to introduce new and flexible schemes to address mobility challenges of women scientists and technologists. Similarly, programmes and schemes are needed to allow re - entry of women in science and business careers after they have fulfilled their post - marriage family commitments to allow individuals, their families and the nation benefit from their true economic / intellectual potential.

A significant proportion of Pakistan's public R&D expense (approx. 60%) is spent on funding defence research, while rest is spent for funding research in R&D organizations / universities. There are no separate funds allocated for 'development' i.e. conversion of research results into products and processes. As referred earlier, unlike most developed and newly industrialized countries, the public policy in Pakistan is not yet successful in stimulating private R&D through effectively instituting and administering incentives such as tax rebates on expense(s) made on R&D by private enterprises, tax credits, awarding innovation grants, subsidizing carrying out of the feasibility studies, providing risk capital and so forth. The funding mechanisms for research should be improved by simplifying administrative and financial procedures in order to facilitate research scientists / engineers in performing their duties. The R&D organizations of the country should have an enhanced financial autonomy that will result in a focused approach, initiation of longer term research projects, better utilization of human / financial resources, and improved decision making processes.

Applied research needs to be stimulated through incentives such as the licensing of technology developed by R&D institutions / universities, process re - engineering, raw material substitution with local alternatives, providing education, training and opportunities for skills enhancement to the knowledge and technical workforce, creating technology based spin - offs, etc. There is a need to establish certain bridging institutions for promoting R&D efforts through setting - up of engineering centres, technology brokers, industrial parks and incubation centers to strengthen / reinforce linkage between public research institutions and industrial concerns. Dissemination of results and updates of national and international ST&I developments need to be made to the researchers / scientists across the country. Pakistani R&D organizations should be encouraged to establish branches in foreign countries, and foreign R&D organizations may be allowed and encouraged to establish operations in Pakistan. Efforts should be made to establish / institute scientific information networks among the local and international R&D organizations, focusing on - site R&D activities and co - development of technologies.

There is a need to understand the implications of innovation in a country like Pakistan and also examine how its surge may impact the wider economy and society. Two major regularities must be emphasized. First, the collective effect of the broadly - dispersed small improvements has a significant impact on the economic growth as against any individual 'radical' innovation. Second, innovations, discrete or non - discrete, involve interdependencies that spark further down-the-line improvements known as the 'innovative complementarities' spurring cumulative causation. These two phenomena have considerable significance for devising innovation policies that have a desirable impact on intensifying development. Since, Pakistan does not possess the required 'technological and research bedrock', it is therefore, given the conditions, quite advantageous to leverage adoption of foreign technologies and thus emulate best practices that will lead to improving the competitiveness of industry.

As most of the economic activity in Pakistan takes place in traditional 'non hi - tech' quarters, a policy to spur technology - related (economic) transformation would vary across the different sectors of economy. A number of measures towards achieving such ends have been suggested in this document – however, they are just equally vulnerable to rent - seeking, if not implemented with caution.

Targets:

15.1. Ensuring sustained political support through investing in S&T infrastructure, establishing new R&D institutions promoting multidisciplinary research, encouraging programmes and projects formulation through allocation of sufficient funds for basic, applied and developmental research, etc.

15.2. Establishing institutional mechanisms for promoting linkages and coordination among the government ministries, universities, R&D / support institutions and industry.

15.3. Instituting incentives for scientists / technologists working on industry - specific projects. This would include but would not be limited to instituting pecuniary benefits from the proceeds of research contracts, royalty, license fee, etc. and recognizing professional / scholastic accomplishment through conferring medals, national awards etc.

15.4. Devising mechanisms for the pooling of laboratory resources / equipment among R&D organizations, universities and industry across the country.

15.5. Facilitating the small and medium enterprises (SMEs) with technological information, providing R&D support for product / process development, technical training, testing and analytical facilities etc., in order to enhance the quality of their products based on indigenous resources.

15.6. Establishing 'Technology Incubation Centres (TICs)' – they would provide space to the nascent industry / university spin - offs at affordable rates as well as provide them with necessary support for business development, marketing, financing and legal services to facilitate new start - ups. Such Centres may first be established in selected universities and later emulated as components of Technology Parks or stand - alone entities looking after the development of new technologies and industrial products.

15.7. Setting - up of at least one major 'Technology Park' in each province, Azad Jammu and Kashmir, Gilgit - Baltistan and Islamabad Capital Territory preferably to be administered by selected universities.

15.8. Encouraging R&D organizations to set - up 'semi - industrial scale pilot plants' for the manufacturing and marketing of indigenous products developed by them; and then to gradually scale up those that prove successful.

15.9. Developing of a viable 'Metrology, Standards, Testing and Quality System (MSTQ)' to help and facilitate producers in the country in achieving quality standards acceptable in the international markets.

15.10. Attracting foreign direct investment in advanced technological areas through financial / fiscal incentives and through provision of world class physical infrastructure.

15.11. Encouraging local industry to initiate overseas operations in order to get exposure and gain experience of performing in high - tech environment and possibly improve upon their organizational processes.

15.12. Enabling conversion of R&D outputs into social / commercial applications by replicating hitherto successful models as well as establishing new PPP structures.

15.13. Motivating larger industrial enterprises to set - up specialized R&D wings in order to exploit indigenous resources and technologies for sustainable industrial development.

15.14. Fostering resource - optimized, cost - effective innovations across the economy in different technological sectors.

15.15. Establishing 'Innovation Fund' to sponsor projects based on innovative approaches, so as to allow the private enterprises benefit from programmes in national priority areas.

15.16. Creating a robust 'National Innovation System' in order to support the ability / capacity of Pakistan to innovate – especially to adapt and create S&T for economic / societal use.

GOAL 16

To promote Electronic System Design and Manufacturing in the country for economic development, employment generation and increase of exports in this sector.

Electronics manufacturing industry is the largest and fastest growing industry in the world. At present it is estimated at US$ 1.75 Trillion. Industrial base in this sector is negligible in the country while Pakistan is among the major users of electronic goods. By establishing electronics manufacturing industry large number of unemployed youth can be deployed in this industry. For self-reliance of the country promotion of Electronic System Design & Manufacturing industry is essentially required.

Key areas of electronics system design & manufacturing include consumer electronics, IT & Telecom, Automotive electronics, electronic components, chip design, medical electronics, power electronics, LEDs manufacturing and LED lights.

Electronics components/semi-conductor Chips are essential part of any electronic products. For indigenous design and self-reliance in electronics, semiconductor chip design and water fabrication facilities are essentially required. Setting up of chip design centres require less investment as compared to wafer fabrication facility. A lot of foreign exchange can be earned through IC design services to international companies. (India is generating nearly U$ 2 Billion revenues through chip design services). Setting up of chip design centres across the country will provide enabling environment for the semi conductor wafer fabrication industry and will also attract foreign investment in this sector.

The following three components are essential parts of any quality infrastructure; Standards, Metrology, and Conformity assessment.

Each component, strongly interlinked with each other, has a different role to play in a quality assurance system of any economy. In order to increase the export of electronic products in the quality-conscious international market it is essential to produce high quality products which are compliant with global standards e.g. ISO, IEC, EN, etc. Conformity Assessment Bodies (CAB) assess the quality of a product, service, system and human resource according to specific standard by employing methods such as testing, inspection and certification.

Targets:

16.1. To promote chip design and manufacturing industry in the country to achieve self-reliance and promote indigenous design & manufacturing and to achieve turnover of U$ 100 M annually by 2018.

16.2. To increase availability of high-technology manpower in electronic design & manufacturing sector to create enabling environment for local and foreign investment and to achieve target of 500 high-end human resource creation to 500 Masters and 100 PhDs annually by 2017.

16.3. Setting up of semi-conductor wafer fabrication facilities for manufacturing of chips and components.

16.4. Extensive HRD program may be launched in the high-technology area of semiconductor design and manufacturing in collaboration with local/foreign universities to ensure availability of adequate trained/skilled manpower to industry.

16.5. Establishment of Conformity Assessment Centres to facilitate production of quality electronic products.

GOAL 17

To ensure the availability of quality human resources in Engineering sector as per needs of the country.

The importance of Engineering Industry and Manufacturing sector for their contribution towards the GDP of a country can hardly be over-emphasized. Pakistan Engineering Goods Industry, despite being small in terms of size, contribution to GDP and exports, has a large potential to grow and contribute in GDP and exports. The engineering sector is diverse and all its sub-sectors have their own dynamics and value chain. The engineering sector is largely dependent on imports for its inputs, is technology & knowledge intensive and employs relatively more skilled people than other sectors. Owing to continuous need for skill, product design and manufacturing process improvement, it faces altogether a different challenge to compete internationally.

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.

Targets:

17.1. Accreditation/ Re-accreditation of Engineering Programs in higher education institutions of engineering and technology.

17.2. Capacity building and training of Accreditors / Evaluators (PEVs).

17.3. Revision of Regulations of Engineering Education.

17.4. Capacity Building Programs for engineers.

17.5. Engineering Practice Examination (EPE) for elevation of Registered Engineers (REs) to Professional engineers (PEs).

17.6. Constitution of sub-committee on Engineering and manufacturing to formulate technical recommendations/ policy guidelines for the government.

4.6. Science, technology and innovation for social development priorities

Focus Areas:

- ⇨ *Food Security*
- ⇨ *Water*
- ⇨ *Health and Pharmaceuticals*
- ⇨ *Environmental Quality*

GOAL 18

Exploitation of full potential of livestock and agriculture sectors for ensuring national food security.

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[1] 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.

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

[1] Pakistan Livestock Census, 2006

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 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.

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.

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.

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:

Strategy:

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

18.2. 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.

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

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

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

18.6. Reclamation of waterlogged and salinized area in Lower Sindh.

GOAL 19

To take initiatives to address major issues related to water quality, resource, planning & management, aquifer recharging and rain water harvesting.

An arid country, Pakistan depends heavily on annual glacier melts and monsoon rains. Water from these sources flows down the rivers and out to the sea. En route, there are seepages into the ground, where water-bearing rocks or aquifers absorb and store this water. Most parts of the country receive scant rainfall and have little or no access to surface water. Pakistan Water Partnership (PWP) states that in Pakistan the total available surface water is about 153 million acre feet (MAF) and the total ground water reserves are approximately 24 MAF, of which a substantial part has been mined without allowing for natural recharge. Currently estimated at 160 million, the population of Pakistan is set to double in 2.5 decades. This means that the per capita availability of water will decrease. There is likely to be a net decrease, rather than an increase in the country's water resources, due to a number of factors including population growth, climate change, and exploitation of water.

By international standards, Pakistan was already a water-scarce country in 1992 at 1700m3 available per capita, according to UNFPA/Ministry of Population Welfare. By 2003, Pakistan's per capita availability of water declined to the extent that it was categorized as a water-stress country by the World Bank, surpassing Ethiopia and on par with African countries such as Libya and Algeria. Pakistan is now a water-scarce country at 1200 m3 per capita per year.

According to the experts, based on current projections, water availability (per capita) will be 855m3 by the year 2020. We have already used up everything that exists in our water cycle and we do not have additional sources of water to mobilize.

The situation demands that Pakistan must take some drastic steps to manage the water related issues. Following is the details about the targets fixed for various initiatives in this regard.

Targets:

19.1. To constitute sub-committee on Water to advise the government of technical and policy issues.

19.2. To conduct technical assessment survey of water supply schemes.

19.3. To initiate water quality monitoring program in major cities.

19.4. ISO-17025 accreditation of Regional Water Quality Laboratories under PCRWR.

19.5. Capacity building of professionals of water supply agencies.

19.6. Skill development at national Capacity Building Institute for Water Quality Management.

19.7. Application of GIS and hydrological modelling for water resources planning and management.

19.8. Study on recharging depleted aquifers in Balochistan through leaky dam, check structure, inverted well and watershed management techniques.

19.9. Rainwater harvesting in Chagi-Kharan Desert through reservoirs check structures etc.

19.10. Desertification control in Thar and Cholistan through water management practices

19.11. Provision of water quality analytical services to public.

19.12. In-house product development for safe drinking water.

19.13. Reclamation of waterlogged and salinized area in lower Sindh.

19.14. Providing help and support for the implementation of 'National Water Policy – 2009', and 'National Drinking Water Standards'.

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

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

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

GOAL 20

To develop national R&D capacity for improved health facilities, increase vaccine production, and establish centres for herbal and nanomedicine.

Pakistan is amongst the countries where infant and maternal mortality rates are high. Similarly, resistance to existing antibiotics, anti-TB drugs is growing and posing a health challenge. Mental disorders particularly stress related complications such as depression is growing with rapid pace, where women outclass men, and increasing prevalence in young women is posing a serious threat. Non-communicable chronic diseases such as hypertension, diabetes, ischemic heart disease, atherosclerosis, are growing like in other parts of the world, which results in a major economic burden.

There are more than 400 pharmaceutical companies including 25 multinational companies (MNC). The local pharmaceutical industry has developed over the years, focusing primarily on manufacturing “me too” drugs and some of the local units are as good as MNCs if not better. While the main distinguishing feature of MNCs is their focus in research, introducing and marketing their own research products but unfortunately, MNCs are weak in the ensuring proper local R & D units and rely on the research done elsewhere. They can be asked to train manpower in clinical trials and invest locally . Drug testing laboratories are not fully equipped particularly in the skilled manpower, partly because the salary structure in not based on market demand.

Vaccine production is very important to prevent communicable diseases at low cost. To meet the growing requirement of vaccines and to ensure vaccine security, Pakistan should be in a position to produce its own vaccines. The vaccine production units should be developed at universities, labs, R&D institutes, public or private companies. Vaccine production facility at the National Institute of Health should also be upgraded 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. As the EPI vaccines are being provided free of cost by UNICEF through a grant from GAVI, The production of animal and poultry vaccines in the public sector, e.g. at the Veterinary/poultry Research Institutes needs to be increased manifold for meeting the total requirements of the country.

Indigenous herbal wealth is not fully exploited despite of the global resurgence and high market abroad. We sell our raw material such as leaves, stem, roots etc on throw away prices and import the finished products such as herbal teas and medicines at high cost spending valuable foreign exchange. Value addition is not in place. Our neighbouring country (India) has over 100 state funded research Institutes/centers on indigenous medicine; one full fledge university exclusively on Ayurveda medicine exists in Gujrat, but hardly any state funded such Institute is in Pakistan. There is a need that the Government takes full patronage of indigenous herbal wealth and gives it proper status as well as ensures mechanism of quality assurance.

Targets:

20.1. Hydrocracking facility is important to be developed at the national level to manufacture cost effective basic ingredients for the basic pharmaceutical manufacturing.

20.2. Establishment of a World class Clinical Pharmacology Centre in Pakistan

20.3. Strengthening of CBSBR (Centre for Bioequivalence studies and Bioassay Research), University of Karachi as the National Clinical Trial facility.

20.4. Pharmaceutical Technology Park with the provision of venture capital for young entrepreneurs.

20.5. Designation of leading R&D institutes and research centres in universities as state key laboratories for pharmaceuticals development.

20.6. 15-Years tax holiday on manufacturing of basic pharmaceutical ingredients.

20.7. Establishment and strengthening of Bioequivalence Laboratories.

20.8. Mandatory requirement of hiring of at least 5 Ph.Ds in drug related disciplines in every WHO certified industry with 10% tax holidays.

20.9. Inclusion of all kinds of medicines under the national drug regulation authority to ensure quality, safety and efficacy.

20.10. Buy back guarantee by the government for vaccine producers (under national vaccine program).

20.11. Tax holidays on indigenous manufacturing of vaccines.

20.12. R&D Grants to key research institutions for the development of specific vaccines against various diseases (Human/livestock/ poultry).

20.13. Establishment of large animal facility/recombinant vaccine facilities in top universities of the country for vaccine production at pilot plant level.

20.14. Establishment of nanomedicine centre to meet the need for future drug development.

20.15. Manufacturing of basic biomedical equipment locally with 15-years tax holidays.

20.16. Strengthening of PCSIR Peshawar as a WHO recognized herbal medicine centre.

20.17. Complete ban on export of herbal raw material without value addition.

20.18. 15-Years tax holidays for value-added export of standardized herbal extracts/medicines/ botanicals.

20.19. Development of indigenous resources of pharmaceutical products, based on minerals and salts, fermented biomass, slaughter house waste and medicinal plants. Tax incentives and R&D support from the government will be required.

20.20. Establishment of the Herbal Medicine and Botanical Industrial Park with incentivization strategy.

20.21. Designation and strengthening of HEJ Research Institute of Chemistry, University of Karachi as the state key laboratory of the development of herbal pharmaceuticals and other botanicals.

GOAL 21

To improve environmental quality by reducing contaminants, conserving energy and water.

It is generally agreed by most of the analysts and stakeholders that the enforcement and implementation of the existing environmental policy and legislation in Pakistan, has remained by and large nominal and minimal, in virtually all its spheres, including land, water and air, during the past fifteen years, since promulgation of Pakistan Environmental Protection Act (PEPA: 1997). One of the key reasons for this poor performance is that the required environmental solutions are, in many cases, beyond particularly the economic, and generally the technological, human and institutional resources of the public as well as private sectors of the country.

The cost of environmental degradation and climate change mitigation and adaptation is astronomically high on the national exchequer. Pakistan is among top ten most vulnerable countries in terms of climate change. However, considering the climate change impact in recent years. Pakistan is ranked 135th in terms of contribution of Global warming and emits 0.83% of the Global emissions. The major causes of environmental degradation include deforestation, water, air and land pollution while erratic changes in the intensity and frequency of rainfall and temperature, as well as variability of monsoon lead to climate change impacts like floods, droughts, cyclones, loss of biodiversity and agricultural productivity. Resultantly, the climate change impacts are causing major threats in terms of water security, food security and energy security for the country. However the positive impacts of climatic changes are not considered yet. We need many small dams in Balochistan, desert areas of Sindh and Khyber Pukhtunkhuwa province to store this flood water. This water may be used for afforestation in dry areas and increase the agriculture area in Balochistan and Sindh.

The forest sector and agriculture are the major areas to be affected by the climate change impacts. Resultantly we may have our agriculture area reduced, unfavourable conditions for biodiversity and increased risk of floods. The need of the hour is to protect and enhance Pakistan's forest cover and build new dams. Other vulnerable Eco systems include risks to mountain areas in terms of more frequent flash floods and landslides due to increase in frequency and intensity of precipitation. Similarly the climate change impacts may also affect the biological diversity in Pakistan. Increase in temperatures may exceed the ability of many species to adapt to such changes. The situation demands immediate steps to restore and protect the biological diversity of Pakistan.

Ministry of Science and Technology in consultation and coordination with the Climate Change Division, provincial bodies, universities and others concerned to promote innovation, cost effective scientific and technological solutions for protecting environmental degradation and effectively tackling climate change impacts. This should be combined with strict and more effective enforcement of national environmental laws, so that these problems can be effectively dealt with. To tackle the environmental problems, our local R & D organizations should develop and implement the projects in collaboration with national and international universities, international agencies such as Global Environmental Facility (GEF), UNIDO, WWF, IUCN etc., The funding and technical support from these organizations may be helpful for the development of environmental friendly and energy efficient technologies.

Targets

21.1. Support and work in close collaboration with Environmental Protection Agencies and Ministry of climate change, hire environmental professionals and empower them.

21.2. Support R&D in climatology, forest, biodiversity and glacial studies to predict possible future climatic variation and to adjust ourselves accordingly.

21.3. Encourage and support the industrial ecological approach to reduce adverse impact of chemicals on environment.

21.4. Immediately undertake afforestation and reforestation programs with suitable plantation.

21.5. Set up biotechnology incubation centres and centres of excellence in environmental studies, in different universities.

21.6. Promote Public Private Partnership (PPP) in research and development at national, regional and international levels.

21.7. Provide incentives for commercialization of innovations with focus on green manufacturing and green jobs.

21.8. Assistance in meeting the following objectives:

i. Set up cleaner production centres and support cleaner production techniques and practices.

ii. Provide alternate sources of energy (piped natural gas, liquefied petroleum gas, solar energy and micro hydro power stations) through waste to energy like biogas etc. and to provide, alternative jobs, establishing small industries for people living in forest areas to release the pressure on natural forests and upland ecosystem.

iii. Promote the use of ozone friendly substances in line with the provision of the Montreal Protocol.

iv. Promote 3R technique (recycling, reduce & reuse) of waste.

v. Development of municipal waste water treatment systems

vi. Development of cost effective technologies for the control of particulate matter emissions from stationary sources.