NATIONAL SCIENCE, TECHNOLOGY AND INNOVATION POLICY

2022

Government of Pakistan

Ministry of Science and Technology
Islamabad

NATIONAL SCIENCE, TECHNOLOGY AND INNOVATION POLICY 2022

Government of Pakistan
Ministry of Science and Technology
Pakistan Council for Science and Technology
Islamabad
January, 2022

اور وہ آسمانوں اور زمین کی تخلیق
پر غور و فکر کرتے ہیں

سورہ آل عمران آیت نمبر ۱۹۱

یہ کائنات ابھی ناتمام ہے شاید
کہ آرہی ہے دمادم صدائے کن فیکوں

علامہ اقبالؒ

Glossary of Abbreviations

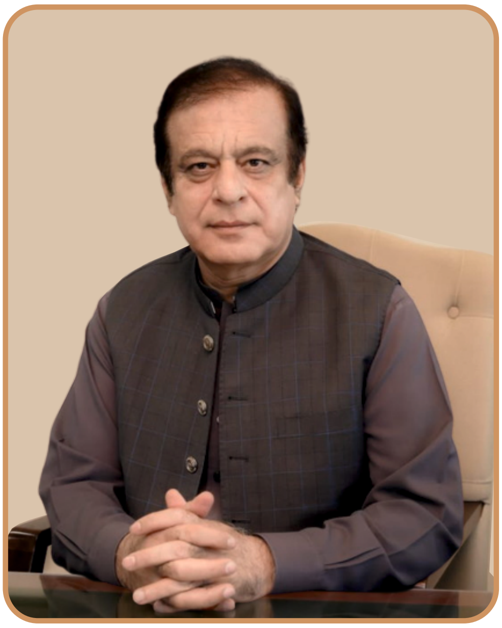
ACOST	Advisory Council on Science and Technology
AI	Artificial Intelligence
ARRI	Ayub Agricultural Research Institute
ATM	Automated Teller Machine
BMC	Business Model Canvas
BoGs	Board of Governors
BPS	Basic Pay Scale
BICs	Business Incubation Centres
CMPID	Civil-Military Integration Promotion Department
COMSATS	Commission on Science and Technology for Sustainable Development in the South
COMSTECH	OIC Standing Committee on Scientific and Technological Cooperation
COSTIND	Commission of Science, Technology and Industry for National Defense
COVID-19	Corona Virus Disease emerged in 2019
CPEC	China-Pakistan Economic Corridor
CPECA	China-Pakistan Economic Corridor Authority
CSA	Chinese Academy of Sciences
CSTI	Council for Science, Technology and Innovation
DCSA	Departmental Chief Scientific Adviser
DDWP	Departmental Development Working Party
ECNCST	Executive Committee of the National Commission for Science and Technology
ECO-SF	Economic Cooperation Organization - Science Foundation
EMI	Electronic Money Institution
FBR	Federal Board of Revenue
FIEDMC	Faisalabad Industrial Estate Development & Management Company
FMCGs	Fast-Moving Consumer Goods

FPCCI	Federation of Pakistan Chambers of Commerce and Industry
GCSA	Government Chief Scientific Adviser
GDP	Gross Domestic Product
GIKI	Ghulam Ishaq Khan Institute of Engineering Sciences and Technology
HEC	Higher Education Commission
HEIs	Higher Education Institutions
HR	Human Resource
IBA	Institute of Business Administration
ICCI	Islamabad Chamber of Commerce and Industry
ICTs	Information and Communication Technologies
ILO	International Labour Organization
IoT	Internet of Things
IP	Intellectual Property
IPO	Intellectual Property Organization
IPR	Intellectual Property Rights
IT	Information Technology
KCCI	Karachi Chamber of Commerce and Industry
KIET	Karachi Institute of Economics and Technology
LCCI	Lahore Chamber of Commerce and Industry
LCI	Lean Canvas for Inventions
LUMS	Lahore University of Management Sciences
MDGs	Millennium Development Goals
MoITT	Ministry of Information Technology and Telecommunications
MoFA	Ministry of Foreign Affairs
MoST	Ministry of Science and Technology
NADRA	National Database and Registration Authority
NARC	National Agricultural Research Centre
NAVTTC	National Vocational and Technical Training Commission
NCST	National Commission for Science and Technology
NED-UET	University of Engineering and Technology

NESCOM	National Engineering and Scientific Commission
NFTP	National Freelance Training Programme
NGOs	Non-Governmental Organizations
NIC	National Incubation Centre
NIS	National Innovation System
NSU	National Skills University
NUST	National University of Sciences and Technology
NVQF	National Vocational Qualification Framework
ORICs	Offices of Research Innovation and Commercialization
OECD	Organization for Economic Cooperation and Development
OII	Oxford Internet Institute
OLI	Online Labour Index
OP	Pakistan One United Nations Programme
PAEC	Pakistan Atomic Energy Commission
PARC	Pakistan Agricultural Research Council
PASHA	Pakistan Software Houses Association
PASTIC	Pakistan Scientific and Technological Information Centre
PBC	Pakistan Business Council
PCST	Pakistan Council for Science and Technology
PIDC	Pakistan Industrial Development Corporation
PIEAS	Pakistan Institute of Engineering and Applied Sciences
PITB	Punjab Information Technology Board
PSA	Principal Scientific Adviser
PSEB	Pakistan Software Export Board
QS	Quacquarelli Symonds Ltd. (A UK company specializing in the analysis of higher education institutions)
QAU	Quaid-i-Azam University
R&D	Research and Development
RPA	Robotic Process Automation
S&T	Science and Technology
SBP	State Bank of Pakistan

SDGs	Sustainable Development Goals
SCCI	Sialkot Chamber of Commerce and Industry
SEZ	Special Economic Zone
SITE	Sindh Industrial Trading Estate
SME	Small and Medium Enterprise
STEM	Science, Technology, Engineering, and Mathematics
STI	Science, Technology and Innovation
STI-MIS	Science, Technology and Innovation Management Information System
STP	Science and Technology Park
STZ	Special Technology Zone
STZA	Special Technology Zones Authority
TEVT	Technical Education and Vocational Training
UN	United Nations
UNSDF	UN Sustainable Development Framework
UNESCO	United Nations Educational, Scientific and Cultural Organization
UK	United Kingdom
US	United States
USA	United States of America
USD	United States Dollar
VC	Venture Capital
VU	Virtual University
WEF	World Economic Forum
WIPO	World Intellectual Property Organization

Message of the Federal Minister for Science and Technology



Science, Technology and Innovation (STI) Policy - 2022 has been formulated in accordance with the Prime Minister's vision of realigning the country to a technology-driven economy. The policy would serve as a game-changer in utilizing knowledge, created through research and development, for product development and technology-based innovation & entrepreneurship leading to job creation and wealth generation. The policy is the result of a wider consultation process with different segments of the society, including federal and provincial public and private entities, scientists, engineers, academicians, industry experts, economists and members of the civil society. Sixty one (61) policy statements are included in the policy, which set the clear roadmap for action to bring about a paradigm shift from the academic impact of R&D to its societal impact. The policy is geared towards socio-economic development of the country with people of Pakistan being the ultimate beneficiaries.

Senator Syed Shibli Faraz
Federal Minister
for Science and Technology

Message of the Federal Secretary Ministry of Science and Technology

In the modern world, no nation can overcome societal developmental challenges without equipping itself with science & technology and embracing a culture of innovation. The quintessence of the current Science, Technology and Innovation (STI) Policy - 2022 is to leverage science, technology and innovation for socio-economic growth to improve the quality of life of the common man. The present policy is multi-disciplinary and cross-sectoral focusing on all segments of the society with well-defined, focused and integrated objectives. The main elements of the current STI policy include adopting modern STI management and governance, providing appropriate regulatory framework, invigorating human capital for driving innovation, use of emerging technologies in all sectors of economic growth and effective science diplomacy, which are pivotal for transforming the country into a technology-based economy. In order to achieve these objectives, the Ministry of Science and Technology envisages its role as an enabler, catalyst and facilitator for the key players of the national innovation system, i.e., universities, R&D organizations and industry. It is expected that all the stakeholders would play their respective roles with passion and zeal in implementing this policy, so that the country joins the ranks of nations outperforming in STI and economic growth.

Dr. Akhtar Nazir
Secretary
Ministry of Science and Technology

Contents

Preface

Science, Technology & Innovation is globally recognized as the linchpin of societal development and economic growth. Recent global developments have reaffirmed the significance of Science, Technology & Innovation for its far-reaching dividends. Being an Islamic Republic, it is not only our national duty but a divine injunction to fully exploit the bounties of nature in deriving benefits out of them. The greatest period of experiential learning and scientific advancements was spearheaded by Muslims of the medieval age in the great centres of learning stretching from Baghdad, Cairo and Cordoba to the far-east end in Samarkand. For a period spanning over half a millennium between the Ancient Greeks and European Renaissance, the international language of science was Arabic, which denotes the dominance of Muslim scientists in that era.

Today, it is a universally recognized fact that the development of a country is strictly tied to its Science, Technology & Innovation base. This linkage is witnessed across the nations and through the course of history. With the onset of COVID-19 pandemic, technology divide between North and South has become even more apparent. At a time when countries are vying for higher positions on the development ladder making the competition stronger and wider than ever before, Pakistan, with fragmented achievements to its credit in the past, is standing at the cross-roads of renaissance in Science, Technology & Innovation. To embark on the journey of STI based development, it needs to derive inspiration from the old Islamic principles of quest for knowledge and build upon its “critical mass” that it has achieved in Science, Technology & Innovation so far.

The Government of Pakistan is cognizant of the importance of Science, Technology & Innovation and has rightly placed the idea of “knowledge-economy” at the heart of its national development agenda. Ministry of Science & Technology, being the custodian of the National STI policy, regards it as a fountain-head from which all other sectors such as health, education, industry, power, environment etc. may derive inspiration for development. The National STI Policy - 2022 reflects the desire of the government to create synergy among various Ministries and Departments at both Federal and the Provincial levels, and calls for the establishment of Pakistan’s first STI Data Repository in this regard. This synergy and coordination will be further enhanced through establishing the quintuple linkages, notable among them are the “civil-military R&D linkages”, which aspires to institutionalize the knowledge and technology spill-over from the military domain to civilian use and vice versa.

Being at its digital tipping point and with the initiation of the mega development project like CPEC, Pakistan is increasingly becoming an investment hub for the past two years. The policy, while recognizing the need for speeding-up efforts for technology-based Startup industry, places them at the central position and articulates sufficient measures to maximize the opportunities for product development and commercialization. Capitalizing on the unfolding digital revolution, the concept of digitally enabled smart cities has been brought forth in the policy; ten (10) smart cities are proposed to be established under the policy to put technologies to practical use for the betterment of the society. As much as the policy stresses on strengthening of the national STI ecosystem, it equally regards STI as a central pillar of its outward discourse, i.e., international science diplomacy.

A sound policy has to bear full relevance to the prevailing conditions of the society at large and it can be deemed successful only if it meets the contemporary challenges. A large number of stakeholders was consulted during the formulation process of the policy to maximize the ambit of its relevance to contemporary challenges. Building on the premise, the policy calls further for formation of diverse working groups of experts for development of products by leveraging scientific and technological knowledge. The technology-based product (goods & services) development assumes crowning position in the policy for its huge potential in garnering import substitution, export enhancement, job creation and wealth generation.

In view of today's epoch-making era, which is characterized by the rapidly evolving technologies, although the policy identifies a set of emerging & frontier technologies of national importance, it is dynamic enough to provide appropriate response to the requirements of changing circumstances during the course of implementation of the policy. The commitment of the Ministry to ensure necessary support for the success of the policy is manifested in the implementation mechanism, which has been embedded within the policy and will progressively unfold as the policy is promulgated.

Executive Summary

1. Introduction

Pakistan, since its independence, has formulated only two science and technology policies, i.e., National Science and Technology (S&T) Policy - 1984 and National Science, Technology and Innovation (STI) Policy - 2012. Implementation of the National STI Policy - 2012 is largely undocumented due to lack of appropriate implementation follow-up and monitoring mechanism. The need for a new STI policy has emanated from the formulation of multiple sectoral policies since the last STI policy in 2012, country's commitment to achieving SDGs, emergence of many disruptive technologies, re-established importance of STI for human wellbeing & survival due to Covid-19 pandemic, initiation of mega development project like CPEC, and changed socio-economic dynamics over the past decade.

2. Enhancing Role of Science, Technology and Innovation in the Societal Development

Pakistan, like many other developing countries, is faced with four major development challenges, viz., meeting basic human needs, achieving rapid economic growth & development, enhancing quality of life, and improving governance. The policy recognizes the pivotal role of technology and innovation in addressing these development challenges, and stresses the need for capacity building in technology development, which is critical in making progress to meet these societal challenges effectively. The policy also calls for transformation of cities into "smart cities" in a phase-wise manner. These smart cities will employ emerging technologies to provide a healthy lifestyle to the citizens through provision of modern facilities like e-governance, modern security systems, efficient transport systems, green energy, sustainable infrastructure, etc. The policy also recognizes the importance of ICT based services, such as internet, for the societal development in the fourth industrial revolution.

3. Adopting 21st Century Approach to STI Governance and Management

The policy emphasizes the critical importance of evidence-based policy-making rather than opinion-based policy-making; which is conceived, evaluated and implemented by the utilization of data & facts. The policy calls for establishment of a data centre to act as an STI research repository for policy makers, researchers, scientists, students, government agencies, industry, etc. The policy realizes the importance of an appropriate compensation and reward system for the scientific community, and suggests measures to remove disparities in pays and allowances amongst scientists working in different organizations. It outlines measures for training & development of scientists & STI managers / leaders, performance-based career path & progression opportunities, reward & recognition system, retention of competent manpower and expedited hiring and promotion mechanisms. To reassure that the state of Pakistan attaches great importance to STI for sustainable socio-economic development, the policy recommends constitutional and legal cover for STI activities in the country.

4. Invigorating Human Capital for Driving Innovation

The regular update in the knowledge and skills of human resource is a critical input for a fully functional STI ecosystem. The policy impresses upon enhanced production of top-quality human resource at all levels, in line with the international benchmarks, to address the major development challenges. Stress is laid upon STEM education at primary, secondary and tertiary level with a focus to produce "industry-ready" human resource. The policy emphasizes production of skilled technology workers & executives for effective navigation of the country's STI ecosystem. The policy also encourages enhanced participation of women in the national STI ecosystem.

5. Transforming Knowledge into Product

The policy attaches utmost importance to indigenous development of technologies and products by leveraging scientific knowledge. It expounds on various measures to strengthen country's knowledge base, applied research outputs, Intellectual Property Rights regime, industry-academia linkages, civil-military R&D linkages and most importantly the technology transfer mechanisms. The policy also underscores importance of specialized & interdisciplinary research groups, and engagement of Pakistani diaspora for development of technologies and products with focus on real-world problems of the industry, economy and society.

6. Promoting Technology based Innovation and Entrepreneurship

For job creation, wealth generation, import substitution and export enhancement, the policy aims to inculcate and promote a culture of technology-based innovation and entrepreneurship in the country. In this regard, investing in research-base, imparting entrepreneurial education & training and establishment of incubation centres & technology parks, along with provision of access to funding networks, offering tax-incentives and favourable regulations for startups have been highlighted in the policy. Establishment & strengthening of national standardization, quality and accreditation systems to ensure international conformance are also important elements of the policy.

7. Focusing Emerging and Frontier Technologies

The policy employs mission-based approach for adoption and exploitation of emerging and frontier technologies as they are being seen as the strong contributors to future economic growth and societal welfare. Consistent monitoring and re-aligning of research funding is required to take account of the emergence of new scientific fields and to optimize ways to discover further new fields. Training programmes will be introduced for production of qualified skilled human resource in the identified emerging technologies, and target-oriented programmes will be launched to boost the development and deployment of frontier technologies, which impact society and economy across the sectors.

8. Revitalizing Science Diplomacy

Cooperation with other countries in the area of science and technology not only raises a country's level of scientific research but also its abilities and competence to uplift the socio-economic conditions of its people. Science Diplomacy can be a useful instrument to reinforce and make better relations amongst nations by addressing common international issues and exchange of scientific & technological resources. The policy impresses upon the three common aspects and elements of science diplomacy along with their effective realization, i.e., science in diplomacy, diplomacy for science and science for diplomacy.

9. Ensuring Policy Implementation

Effective implementation of the policy shall be ensured through the establishment of various supervisory and monitoring mechanisms such as a Steering Committee for Policy Implementation under the chairmanship of the Federal Minister for Science & Technology, a Policy Implementation & Monitoring Advisory Board and a Policy Implementation Coordination Unit.

Vision Mission and Objectives

Vision, Mission and Objectives

Vision

National Transformation through Science, Technology and Innovation

Mission

Making science, technology and innovation the central pillar of sustainable socio-economic development

Objectives

1. **Enhancing** the role of science, technology and innovation in the sustainable development of the society through need-based research.
2. **Adopting** 21st century approach to science, technology and innovation governance and management to enhance its efficiency and effectiveness.
3. **Invigorating** human resource development to drive innovation as per requirements of various sectors of knowledge economy.
4. **Utilizing** knowledge for job creation and wealth generation through balanced focus on all stages from knowledge generation to product development.
5. **Facilitating** technology-based innovation and entrepreneurship through provision of appropriate support structures and mechanisms.
6. **Focusing** emerging and frontier technologies to achieve national socio-economic development goals.
7. **Revitalizing** science diplomacy to safeguard national scientific, societal, economic and diplomatic interests.
8. **Ensuring** implementation of the policy through appropriate policy implementation mechanisms.

Chapter 1

Introduction

CHAPTER 1

Introduction

1.1. National Innovation System (NIS) of Pakistan

There are four main actors in the national innovation system of Pakistan, i.e., R&D organizations, universities, industry and government (Figure 1). R&D organizations and universities are the main actors in knowledge production, while industry is the main actor in knowledge application or utilization. Government provides the environment in which the other three actors function. Society is the ultimate beneficiary of the whole national innovation system.

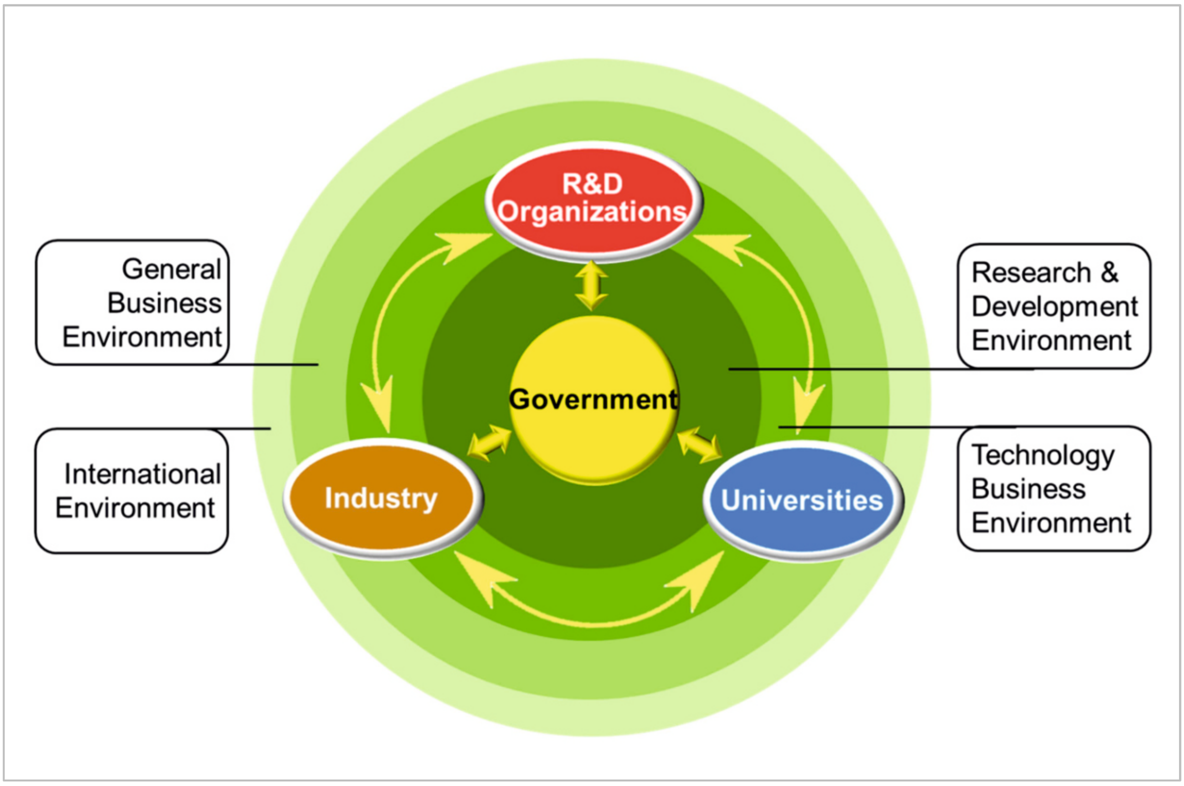


Figure 1: National Innovation System (NIS) of Pakistan[1]

1.1.1. R&D Organizations

There are 67 R&D organizations in the country with more than 250 sub-organizations. All these organizations are in the public sector and mainly conduct applied research. At the federal level, there are 30 R&D organizations, comprising 90 sub-organizations, working under 11 different federal ministries. Some of these R&D organizations have extended organizational structures, e.g., Pakistan Atomic Energy Commission (PAEC) has 5 major sub-organizations working under its administrative control, while Pakistan Agricultural Research Council (PARC) consists of 16 sub-

---

[1] Tariq Bashir.2021. Evolution of national science, technology and innovation policies in Pakistan [submitted manuscript]

organizations and research stations, and one of these sub-organizations, i.e., National Agriculture Research Centre (NARC) consists of further 16 R&D institutes. Federal R&D organizations perform R&D activities in different fields covering almost all major areas of science and technology ranging from agriculture to space technology.

Major federal R&D organizations are semi-autonomous bodies, with their own Board of Governors (BoGs) and heads of these organizations being responsible for execution of research and development activities in their respective organizations. However, practical autonomy of these organizations may vary depending upon their administrative ministry and actual legal framework. There is also a disparity in the salary structures and fringe benefits among the organizations working under different ministries. At present, R&D organizations working under the Ministry of Science and Technology have the least favourable salary structures compared to the organizations working under other ministries. Disparity in the salary and incentive structures among organizations working under different ministries as well as of R&D organizations with universities has become a demotivating factor for the scientists of disadvantageous organizations. Many organizations are also suffering from shortage of manpower; some are working at less than 50 percent of their sanctioned strength. The situation is further compounded by the failure of administrative ministries to timely appoint heads of the organizations. There is always a lag-time between the two successive heads; sometimes the lag-time becomes even bigger than the one whole tenure of the head.

Appointment of heads of R&D organizations based on general qualifications and experience, without considerations of specific requirements of aptitude, experience and skills to successfully run the concerned organization, is also an important matter, which needs rectification. In some organizations, heads are invariably appointed from within the organization, while in others, heads are generally appointed from outside the organization. In the latter case, lack of knowledge of organizational culture, working, core capabilities, and sometimes even of “real functions” of the organization, coupled with the absence or sedentary institutional decision making mechanisms may result in the significant change in organizational direction from one head to the next, which adversely affects organization’s performance in terms of both efficiency and effectiveness.

At the provincial level, there are 35 R&D organizations, comprising 160 sub-organizations, which are working under 14 different provincial departments. Major R&D organizations in the provinces undertake research and development activities in agriculture and related areas, and have huge infrastructures. For example, Agriculture Research Institute, Quetta is comprised of 33 directorates and field experiment stations, while Ayub Agricultural Research Institute (AARI), Faisalabad consists of 27 institutes, with further 57 research stations, etc. working under these research institutes.

Provincial R&D organizations work under the direct administrative control of the provincial departments, which make decisions in line with the federal government's STI policy and are responsible for implementation of the policies and execution of STI activities in the organizations working under their administrative control. In the past couple of decades, a system of contractual appointments has been introduced by some of the provinces in place of permanent appointments in the R&D organizations, which does give flexibility of hire and fire in case of non-performing employees but it also has its own demerits. Contractual appointments coupled with low salaries make provincial R&D organizations less attractive for the brilliant young scientists than employment in universities and other non-scientific careers.

1.1.2. Universities

There are 232 HEC-recognized universities and degree awarding institutions in the country. Universities exist both in the public and private sector, and undertake basic as well as applied research. Major volume of R&D activities, however, is undertaken in the (141) public sector universities as compared to (91) private sector universities. There are also 110 research institutes as well as 54 research cum educational institutes under the administrative control of universities. Most of the universities are 'general' universities undertaking educational and R&D activities in multiple disciplines. However, there are also some 'mono discipline' universities predominately focusing on one discipline such as agriculture, medical or engineering and technology.

Since the establishment of the Higher Education Commission (HEC) in 2002, the number of universities in Pakistan has increased manifold, i.e., 34 in 2000 to 232 in 2021. Total enrollment at the university level has also increased and reached to 1.87 million[2] in 2018, however, the overall participation rate in the tertiary level education still remains extremely low (only 9 percent in 2018), compared with 29 percent in neighboring India and 21 percent in Bangladesh. As per UNESCO Institute of Statistics, the number of outbound Pakistani tertiary level students was 58,821 in 2018, showing more than 88 percent growth in the last decade, which may be, at least partially, attributed to the shortcomings in the national higher education system. However, some international students from Muslim-majority developing countries like Somalia, Sudan, Yemen, and, most notably, neighboring Afghanistan, who pursue studies in Pakistan, where they can access education of higher quality than they can at home[3].

Despite the enhanced capacity of the national universities, indicated by the significant increase in the production of PhDs, which has risen from only 202 per

---

[2] UIS website: http://data.uis.unesco.org/
[3] https://wenr.wes.org/2020/02/education-in-pakistan

year in 2001 to 1,325 per year in 2014[4], our universities still have a long way to go to compete with the top universities in the world. As per QS World University Rankings 2021[5], no Pakistani university is included in the top 100 universities of the world, and only three Pakistani universities are included in the top 500 universities of the world. National University of Sciences and Technology (NUST), Islamabad, which has been ranked at the 355th position in the world, is the highest ranked university in Pakistan. Pakistan Institute of Engineering and Applied Sciences (PIEAS), Islamabad and Quaid-i-Azam University (QAU), Islamabad are placed at the 373rd and 454th position, respectively.

One big challenge for the higher education sector in Pakistan is to build a culture of innovation in the universities, where contribution to the society through solving real-world problems of the country, becomes one of the prime objectives of faculty as well as students. Secondly, earning of universities through generating IPRs is negligible, therefore, most of the universities are dependent on public exchequer to meet their recurring and development expenditure. For that, there has to be a paradigm shift from 'scholar-driven' to 'demand-driven' research, avoidance of thinly spreading human and financial resources, and establishment of strong linkages with the end-user.

To facilitate the commercialization of research results and enhance linkages with the industry, HEC has initiated programmes to support the establishment of the Offices of Research, Innovation and Commercialization (ORICs) and Business Incubation Centres (BICs) in the universities to provide basic infrastructure and allied facilities for researchers and young entrepreneurs who are interested in developing early-stage business ventures. Currently, ORICs have been established at 74 universities[6], while BICs have been established at 30 universities[7]. Under the World Intellectual Property Organization (WIPO) TISC Programme, Technology and Innovation Support Centres (TISCs) have also been established at 38 universities[8] with the collaboration of the Ministry of Science and Technology (MoST), Intellectual Property Organization (IPO) and Higher Education Commission of Pakistan (HEC). However, the importance of university-industry relationships still has not been fully recognized in the country. A recent study showed that almost half of the universities still do not have a formal policy that allows faculty staff to engage in external activities, including consultancy work for industry[9]. No or few rewards for academics to work with industry, poor knowledge of industry-relevant needs, insufficient

---

4 Mapping Higher Education in Pakistan. http://www.technologyreview.pk/mapping-higher-education-in-pakistan/

5 https://www.topuniversities.com/university-rankings/world-university-rankings/2021

6 https://hec.gov.pk/english/services/universities/ORICs/Pages/Established-ORIC's.aspx

7 https://hec.gov.pk/english/services/universities/EBIC/Pages/Established-BICs.aspx

8 https://hec.gov.pk/english/services/universities/ORICs/Pages/Established-TISC.aspx

9 Khaleel Malik, Tariq Bashir and Tariq Mahmood Ali. 2021. University-industry collaborations in Pakistan: current challenges and future opportunities. (*accepted by Foresight, 2nd March 2021*)

experience in new product development & commercialization, and inadequate equipment base & facilities are the main factors for university researchers hampering university-industry linkages.

1.1.3. Industry

As per Pakistan Statistical Bureau's Census of 2015-16 (latest available data), there are 42,262 manufacturing industrial units in Pakistan comprising 37,347 small, 3,598 medium and 1,317 large units. The share of industrial sector in the national GDP is less than 20 percent. The Textile industry is the largest manufacturing industry in Pakistan, which is the 8th largest exporter of textile products in Asia. Cotton, textile production and apparel manufacturing account for around 65% of the merchandise exports and almost 40% of the employed labour force. While food and beverage processing industry is the 2nd largest industry accounting for 27% of the value-added production and 16% of employment in the manufacturing sector. Other major industries include cement, fertilizer, edible oil, sugar, steel, tobacco, chemicals, and machinery.

In general, family-owned business mindset prevails in the industry with very little persuasion for innovation. Hence, industry mainly remains non-innovative and operates at the lower level of technology. There is lack of automation of the production systems and little realization of the need of R&D. For these deficiencies, the industry points towards limited access to finances, non-availability of the 'industry-ready' university graduates, lack of well-trained technician-level workforce required by the industry, and sometimes towards overregulation as well. Although, the industry generally operates at the lower level of technology, however, it does not feel the need to collaborate with the local universities or R&D organizations to upgrade its technology or develop new products. The reason may be that the Pakistani firms generally develop very few new products; especially high tech or high quality products, or they do not consider the universities to be reliable partners.

1.1.4. Government

Government provides the environment in which other three actors of the national innovation system function. The national innovation system environment consists of multiple layers, which can be described as:

- *Research & Development Environment*: It is layer of the environment consists of the elements, which directly impact the capacity and performance of the main actors of the national innovation system. STI policy, R&D funding mechanisms, R&D infrastructure, higher education policy, R&D incentives for industry, intellectual property policy & laws etc. can be cited as the examples.
- *Technology Business Environment*: It is the second layer of the national innovation system environment and consists of elements such as the

- innovation incentives for industry, startup policy, venture capital market, technical standards, technology regulations, technology business infrastructure, technology education & training system etc.
- *General Business Environment*: It influences the performance of the national innovation system through its impact on the final outcome of the ecosystem. General Business Environment is affected by the industrial policy, ease of doing business, monetary policy, energy policy & infrastructure, commerce & trade policy, financial market, labour market, communication & transport infrastructure, education system etc.
- *International Environment*: International Environment also influences the national innovation system through environment elements such as international competition, globalization, international obligations / agreements, international trade etc.

1.2. Global Competitiveness of the National Innovation System of Pakistan

Pakistan's current status of global competitiveness is indicated by its very low rank in the Global Competitiveness Index, where it is ranked 110th out of 141 countries in the 2019 edition of index (latest available ranking)[10]. Among its South Asian neighbours, it has the lowest rank while India holds the top ranked (68th) position. The situation is similar in the Global Innovation Index, where Pakistan has been ranked 99th among 132 countries in the year 2021. Whereas Turkey, India and Iran are at the 41st, 46th, and 60th position, respectively. Pakistan's lower ranking in these influential global indices, *inter alia*, may be linked to its relatively less-developed and low-performing national innovation system.

Pakistan has 157,194 researchers in terms of 'headcount' and 82,921 in terms of fulltime equivalent[11]. The total annual R&D spending of the country is more than Rs. 76 billion[12], which seems reasonable in the context of the local socio-economic realities. However, major portion of this is spent as establishment expenditure. Resultantly, achievements of the national innovation system of the country in terms of technology development are not noteworthy. During the year 2020, only 20 patents were granted to Pakistan compared to 641 of Indonesia, 2,301 of Turkey, 3,294 of Iran and 4,988 of India[13]. So, not surprisingly, the effectiveness of the country's national innovation system to contribute to the economy and society,

---

[10] http://www3.weforum.org/docs/WEF_TheGlobalCompetitivenessReport2019.pdf

[11] Data collected by the Pakistan Council for Science and Technology, Islamabad (data for 2019, which is the latest available data)

[12] Includes R&D expenditure of universities and federal & provincial R&D organizations but excludes expenditure of defence R&D organizations and industry.

[13] WIPO website: https://www3.wipo.int/ipstats/index.htm?tab=patent

through technology development and commercialization, has become a big cause of concern for the policy makers.

Considering total number of researchers and total national R&D spending, the apparent contributions of the national innovation system to the economy or society do not give a rosy picture. However, Pakistan's annual R&D expenditure, which is around PPP$ 2.6 billion[14], is much less compared to the developed countries like the United States (PPP$ 581.6 billion) and Japan (PPP$ 176.8 billion) as well as to the developing countries like China (PPP$ 554.3 billion), India (PPP$ 68.2 billion) and Brazil (PPP$ 41.1 billion)[15]. As percent of GDP, Pakistan's annual R&D expenditure is 0.18% of GDP (2019- latest data), which is much less than the World average (1.7%) as well as average for the South and West Asia (0.6%). It is also much less than one percent of GDP, which has been recommended by the Scientific Advisory Board of UN Secretary General for the developing countries[16].

Analysis of the Global Innovation Index 2021 at the indicator level reveals interesting facts. Pakistan has a relatively higher rank in the researchers / million population (75th), and relatively lower rank in the gross expenditure on R&D (88th), which may indicate that country's financial resources are thinly spread as compared to other countries. Higher rank in scientific & technical articles (49th), and lower rank in patents (88th) suggests that there is a lesser focus on applied and "patentable research" than that on "publishable research".

Pakistan is modestly ranked in Ease of Doing Business Index; 108th out of 190 economies, however, it has made a tremendous improvement in the last two years. With a 39-rank jump, Pakistan was recognized as the top reformer in South Asia and sixth reformer in the world in Ease of Doing Business Index 2020 rankings. Pakistan's startup ecosystem is still in its embryonic stage compared to other nations of the world. In the Global Startup Ecosystem Rankings 2020, Pakistan is ranked 82nd among the top 100 countries, which have been ranked in the index; way behind neighbouring China (14th) and India (23rd). China and India have 4 and 6 cities in the list of Global Startup Rankings of Cities, respectively, while Pakistan has none. The highest ranked city of Pakistan is Lahore, which is at the 271st place.

---

[14] This excludes R&D expenditure of defence R&D organizations and industry.

[15] UNESCO Institute of Statistics: http://data.uis.unesco.org/

[16] The Future of Scientific Advice to the UN: A Summary Report to the Secretary-General of the UN from the Scientific Advisory Board. Paris, France: United Nations Educational, Scientific and Cultural Organization, 2016.

1.3. Science, Technology and Innovation (STI) Policy and Decision Making in Pakistan

1.3.1. Parliamentary Oversight of STI Policy and Decision Making

The parliamentary oversight of STI policy and decision making in Pakistan is provided through the Standing Committees of the Senate and the National Assembly on Science and Technology. Currently, the Standing Committee of the Senate on Science and Technology is comprised of 14 members belonging to six political parties as well as independent members. While the Standing Committee of the National Assembly on Science & Technology is comprised of 21 members belonging to three major political parties of the country. The Federal Minister for Science and Technology represents both the Standing Committees as an ex-officio member.

All the bills and other important matters relevant to science and technology at the national level are referred to these Committees, which examine them and accordingly give their recommendations. The Committees also oversee the functioning of the Ministry of Science and Technology and other ministries with STI components as well as different S&T organizations. The Committees look into the matters of ministries and S&T organizations related to the legislation, administration, expenditure, public petitions etc., and make recommendations for improvement.

1.3.2. Main Actors in STI Policy Formulation

Overall national system of governance of STI policy in Pakistan is illustrated in the Figure 2. National STI policy in Pakistan is formulated by the Ministry of Science and Technology (MoST), however, other sectoral policies may also have STI components. National STI policy relates to the overall promotion, development and application of science, technology and innovation in the country, while the sectoral policies are limited to the STI related to the sector or sphere of functions of the concerned ministry.

MoST is the national focal point for all important matters regarding science and technology including developing STI policies and plans. It is also mandated to promote applied research for economic growth and provide guidance to federal and provincial scientific and technological institutes in the national priority areas of research. Pakistan Council for Science and Technology (PCST), working under the administrative control of MoST, has the responsibility to assist MoST in policy formulation. PCST also works as the secretariat of the National Commission for Science and Technology (NCST), which is headed by the Prime Minister of the country. NCST is meant to provide guidance to scientific and technological effort at

the national level, and has an overarching function of policy and coordination across various government ministries and agencies but it does not have any administrative function.

Policies of the federal ministries, looking after the affairs related to information technology & telecommunications, defence, energy, food & agriculture, health, industries & production, environment & climate change, higher education, etc., also include STI measures related to these sectors, which are usually discussed in more detail in those sectoral policies.

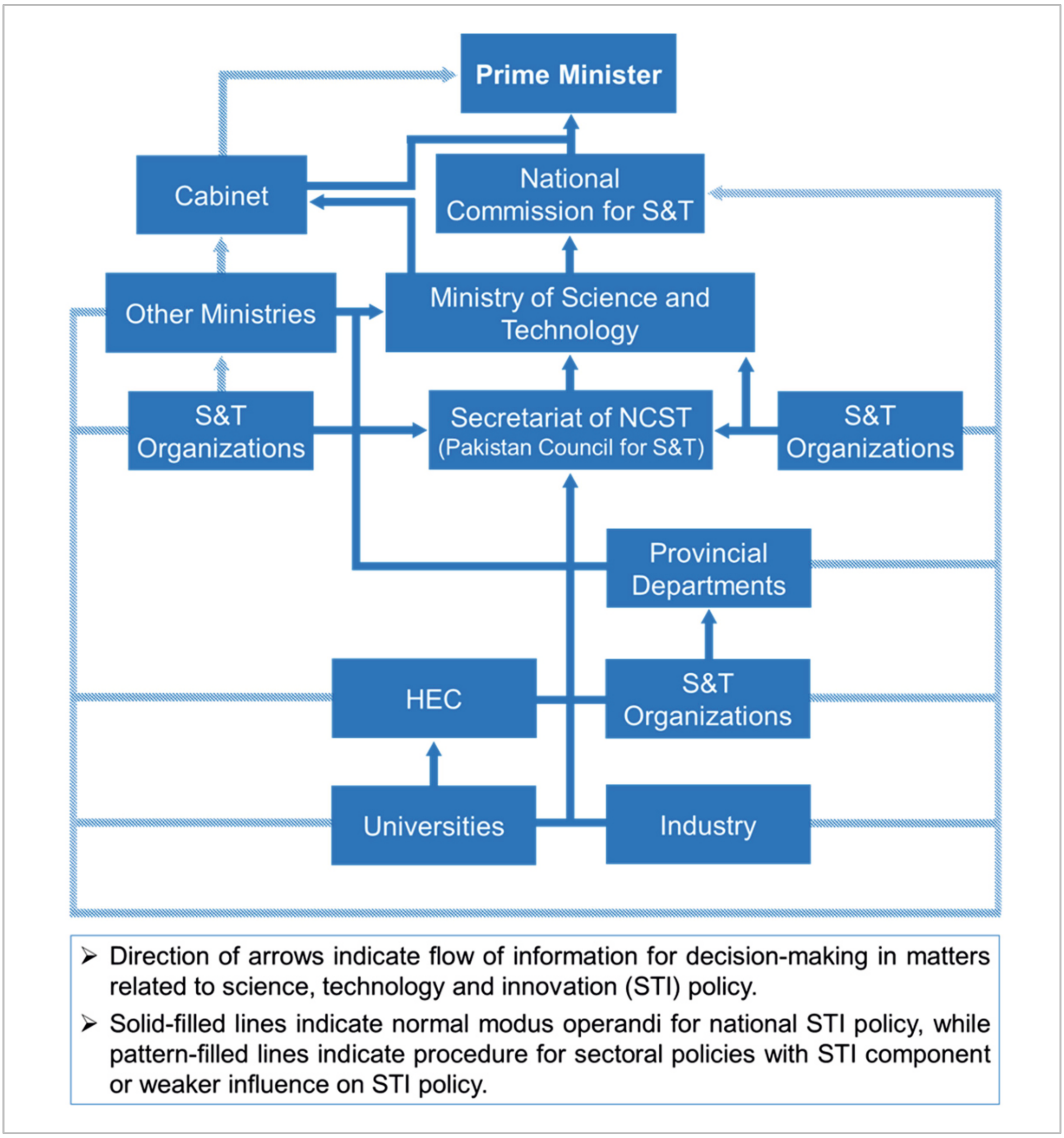


Figure 2: National system of governance of science, technology and innovation policy in Pakistan[17]

---

[17] Tariq Bashir.2021. Evolution of national science, technology and innovation policies in Pakistan [submitted manuscript]

1.3.3. Overview of Evolution of National STI Policies

Policy makers in Pakistan have realized the importance of science and technology for socio-economic development right from the beginning, which is evident from the fact that some important S&T organizations were established within the first few years of the creation of Pakistan. Central Cotton Committee, Food and Agriculture Council, Department of Scientific and Industrial Research, Pakistan Medical Research Council, and Atomic Energy Council were all established within the first ten years of independence.

However, the first policy document came out in 1960 when report of the National Scientific Commission of Pakistan was published. Since then, the National Science and Technology Policy - 1984, Recommendations of the 2nd Meeting of NCST - 2000, and National Science, Technology and Innovation Policy - 2012 have been formulated. The draft of National Technology Policy - 1993 was also developed after extensive consultation exercises, however, it could not reach to the Cabinet for approval.

Report of the Scientific Commission of Pakistan - 1960 was mainly focused on the supply side of science and technology as it concentrated on tasks and problems of science in Pakistan, organization of defense research, career and status of scientists, utilization of results of research, and facilities and resources for research. There was almost no mention of the development of absorption capacity in industry or creation of linkages between research establishments and industry. The National Science and Technology Policy - 1984, however, highlighted importance of technology development along with recommending measures for improving university research, scientific and technical manpower, service conditions and incentives for scientists and technical manpower, promotion of science and technology in society, and financing of science and technology. The policy also underscored the significance of the international liaison for making advancements in the field of science and technology.

Recommendations of the 2nd Meeting of NCST - 2000 paid relatively more attention to the technology development and industrialization in the country than the previous policies. Human resource development, up-gradation of the R&D infrastructure, restructuring of R&D organizations, strengthening of policy, coordination and management structure, and improvement of funding mechanism for R&D were also major target areas of the recommendations.

The National Science, Technology and Innovation Policy - 2012 was even more focused on the technology development than the previous policies. In this regard, it not only emphasized the indigenous technology development but also highlighted importance of internal as well as international technology transfer. The policy also dwelled upon the issue of creation of absorptive capacity in the industry.

STI planning and management structure, human resource development, and international cooperation were other important intervention areas of the policy.

Taking the narrower approach of the national innovation system, universities, R&D organizations and industry are the main actors in the innovation system. Universities and R&D organizations mainly represent the supply side of innovation, while industry represent the demand side of innovation. Review of the S&T policies of Pakistan from supply and demand perspective shows a clear change in the focus of policies over time, from being predominantly supply-push to relatively more demand-driven. Another change is the comparatively more focus on the creation of linkages among the actors of national innovation system. It may be concluded that with the time, science and technology policies in Pakistan have become more balanced in the context of national innovation system approach.

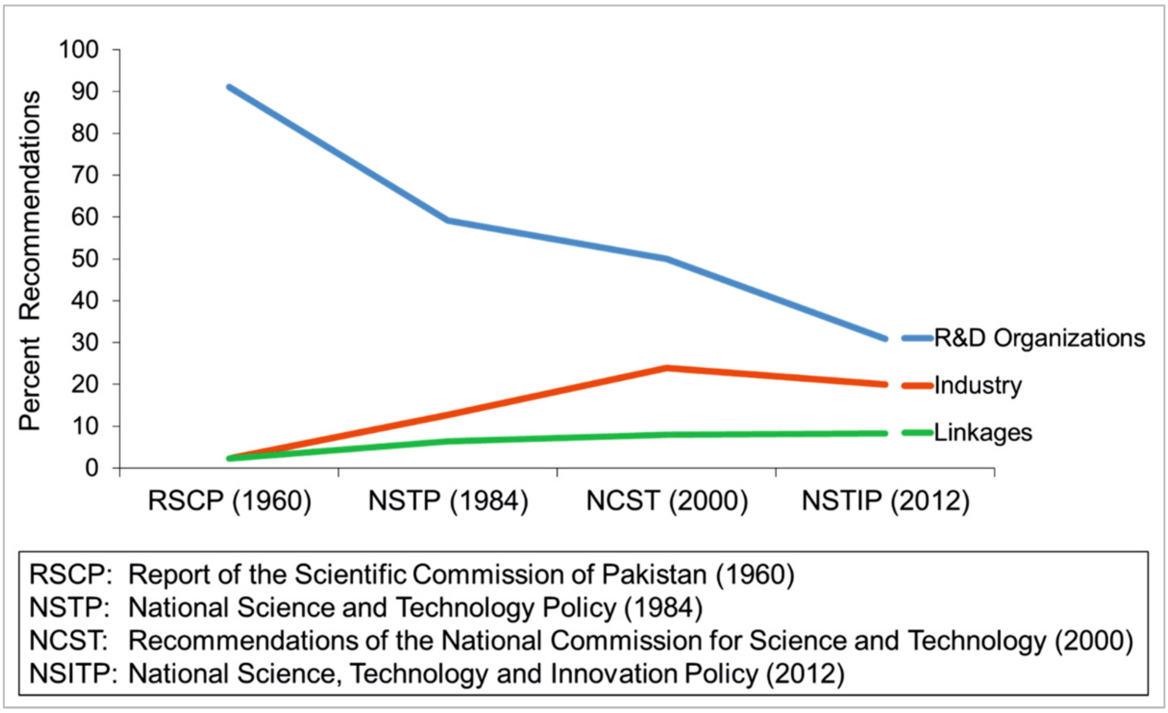


Figure 3: Focus-shift of national science, technology and innovation policies in Pakistan over time[18]

1.3.4. Implementation Status of the Previous National STI Policy

Implementation gap analysis of the previous National STI Policy (i.e., National STI Policy - 2012) reveals that after almost a decade of its approval in 2012, by and large the policy remained unimplemented. A couple of documents, i.e., the National STI Strategy 2014-18 (2014), and later on the National STI Strategy and Action Plan - 2018 were prepared as a follow-up of the STI Policy - 2012, however, these documents did not make much difference as far as implementation of the policy is

[18] Tariq Bashir.2021. Evolution of national science, technology and innovation policies in Pakistan [submitted manuscript]

concerned. Main reasons identified for the lack of the implementation of the policy are as under:

- No serious efforts were made on consistent basis to implement the policy.
- No funds were allocated to implement the policy.
- Ministry of Science and Technology (MoST), supported by the Pakistan Council for Science and Technology (PCST), was chiefly responsible for implementation of the policy, however, no efforts were made for capacity building of both the organizations for the purpose.
- It was recommended in the policy to strengthen technical wings of MoST for evaluation and monitoring of R&D activities, however, it was never done.
- Similarly, there was a recommendation regarding establishment of a well-staffed STI Policy Cell in PCST. In an attempt to implement the recommendation, PCST submitted a PC-1 titled “Establishment of a Cell at PCST for Implementation of the National STI Policy - 2012”, however, it was not approved.
- No initiatives were taken to implement overarching recommendations of the policy such as:
    - Declaration of the political will that S&T capacity building would be a central pillar of national development strategy and the R&D expenditure would be enhanced to 1.0% of GDP by 2015 and 2.0% by 2020.
    - Commitment to create a long-term non-partisan STI policy with the consensus of all stake-holders and putting in place a legal framework for ensuring continuity of the policy and allocation of required funds.
- While approving projects, DDWP of MoST did not consider whether they were in-line with the STI Policy or not.
- Implementation of the STI policy was not deemed important to achieve goals of national economic development agenda, hence, while approving the S&T / R&D projects, the Planning Commission did not consider whether they were in-line with the STI policy or not.
- No policy implementation monitoring mechanism was adopted.

1.3.5. Need for the New STI Policy

- *Support to the National Sectoral Policies*

National STI policy supports achievement of goals in all the other sectors of economy such as agriculture, industry, trade, commerce, health, education, environment, tourism etc. Since approval of the last STI Policy in 2012, many new sectoral national policies have been formulated. There are many initiatives suggested in these sectoral national policies where science, technology and innovation can contribute in implementation of those initiatives. This necessitates formulation of the new national STI policy to align STI activities with goals of the sectoral national policies.

- *Sustainable Development Goals (SDGs)*

The Sustainable Development Goals (SDGs) were adopted by all United Nations Member States in 2015 as a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030. As a demonstration of political commitment and ownership, Pakistan integrated the SDGs into its national development agenda in 2016, and thus, became the first country to adopt SDGs 2030 agenda through the unanimous resolution of the Parliament[19]. A dedicated SDGs Section was also formed at the federal level in the Ministry of Planning, Development & Special Initiatives for monitoring and coordination[20]. In 2018, the Government of Pakistan and the UN in Pakistan signed the UN Sustainable Development Framework (UNSDF)[21], also known as the Pakistan One United Nations Programme III (OP III) 2018-2022. This Framework is a medium-term strategic planning document with planned results focusing on ten key outcomes, which are identified through extensive consultation with multiple stakeholders and in alignment with Pakistan’s development priorities.

Pakistan aims to continue to work towards achieving the SDGs through innovative, targeted and focused implementation strategies in the social, economic and environmental fields, which cannot be made possible without interventions of the science, technology and innovation.

- *CPEC- the Mega Development Project*

China-Pakistan Economic Corridor (CPEC) is a part of the larger Belt and Road Initiative (BRI) of China, which was announced in 2013 to improve connectivity, trade, communication, and cooperation with a large number of Asian

---

[19] https://www.sdgpakistan.pk/
[20] https://www.sdgpakistan.pk/web/about
[21] https://pakistan.un.org/en/sdgs

and European countries. CPEC, with the estimated worth of US$ 68 billion, is the largest investment Pakistan has attracted since its independence. It is also the largest investment China has made in any foreign country. In some ways, CPEC may be compared to the Marshall Plan for the rebuilding of post-World War II Europe in its potential impact on Pakistan; that is why it is being called a game changer for Pakistan.

Initially, CPEC initiatives will focus on energy and transport infrastructure development in Pakistan while in the 2nd stage focus will be on the industrial cooperation that is expected to bring a positive change in the socio-economic development in Pakistan. Talking about the motivations for the Belt and Road Initiative, President Xi Jinping in his speech in 2017 stated that "*we should pursue innovation-driven development and intensify co-operation in frontier areas such as digital economy, artificial intelligence, nanotechnology and quantum computing, and advance the development of big data, cloud computing and smart cities so as to turn them into a digital silk road of the 21st century*"[22]. It is important for the S&T sector to be ready to contribute to and benefit from the mega project like CPEC.

- *Influx of Disruptive and Emerging Technologies*

During the last decade or so, many new disruptive and emerging technologies have arrived, which may have glaring consequences such as:

- Unemployment due to disruptive and emerging technologies such as artificial intelligent, advancements in industrial robotics, automation etc.
- Development model of utilizing cheap labour to manufacture export-oriented goods, adopted by many developing countries like South Korea, China etc. may become defunct very quickly.
- More jobs will be available in business related to emerging technologies, requiring specialized skills, rather than in traditional sectors.
- New technologies may lead to new industries, eliminating many existing industries.

Roles of many technologies like biotechnology, nanotechnology, materials science, artificial intelligence, internet of things, augmented reality, blockchain, big data etc., for socio-economic development of nations, have become more prominent and new applications of these technologies have emerged. In order to fully benefit from these technologies, appropriate policy measures for their development and application are required.

---

[22] Xi, J. (2017a), Work Together to Build the Silk Road Economic Belt and The 21st Century Maritime Silk Road, Opening speech, The Belt and Road Forum for International Cooperation

- *COVID-19: National Urgent Priority*

The current COVID-19 pandemic has clearly shown the critical importance of investment in science, technology and innovation for our capacity to overcome urgent societal challenges. In pandemics, science, technology and innovation can contribute in several areas such as understanding the disease, development of low-cost rapid tests & screening methods, development of vaccines and medicines, development of ventilators and other such equipment, development of applications for tracking and monitoring the spread of disease, determination of impact on the population, economic recovery based on the development of digital platforms for health, education and work, etc.

To effectively deal with future pandemics, we need to enhance our readiness level through taking appropriate STI policy measures to develop capacity for early detection, response, and control of the diseases as well as for production of drugs and vaccines.

- *Robust Policy Implementation Mechanism*

As stated in the preceding Section, implementation of the STI Policy - 2012 largely remained undocumented, which indicates the need to develop a robust policy implementation monitoring mechanism and make it an integral part of the policy to enhance chances of the policy implementation as well as effective ex-post evaluation of policy implementation.

Chapter 2

Enhancing Role of Science, Technology and Innovation in the Societal Development

Chapter 2

Enhancing Role of Science, Technology and Innovation in the Societal Development

2.1. Key Societal Development Challenges for Science, Technology and Innovation

Life in the modern world cannot be imagined without technology. Technology has changed the way we live, work, travel, play, interact with others, spent leisure time, or even practice religious norms and duties. In today's world, every sphere of life is influenced by some kind of technology. Pakistan, like many other developing countries, is faced with four major development challenges, i.e., meeting basic human needs, achieving rapid economic growth & development, enhancing quality of life, and improving governance (Figure 4). Technological advancements and innovation can make significant contributions to make progress in addressing all these development challenges.

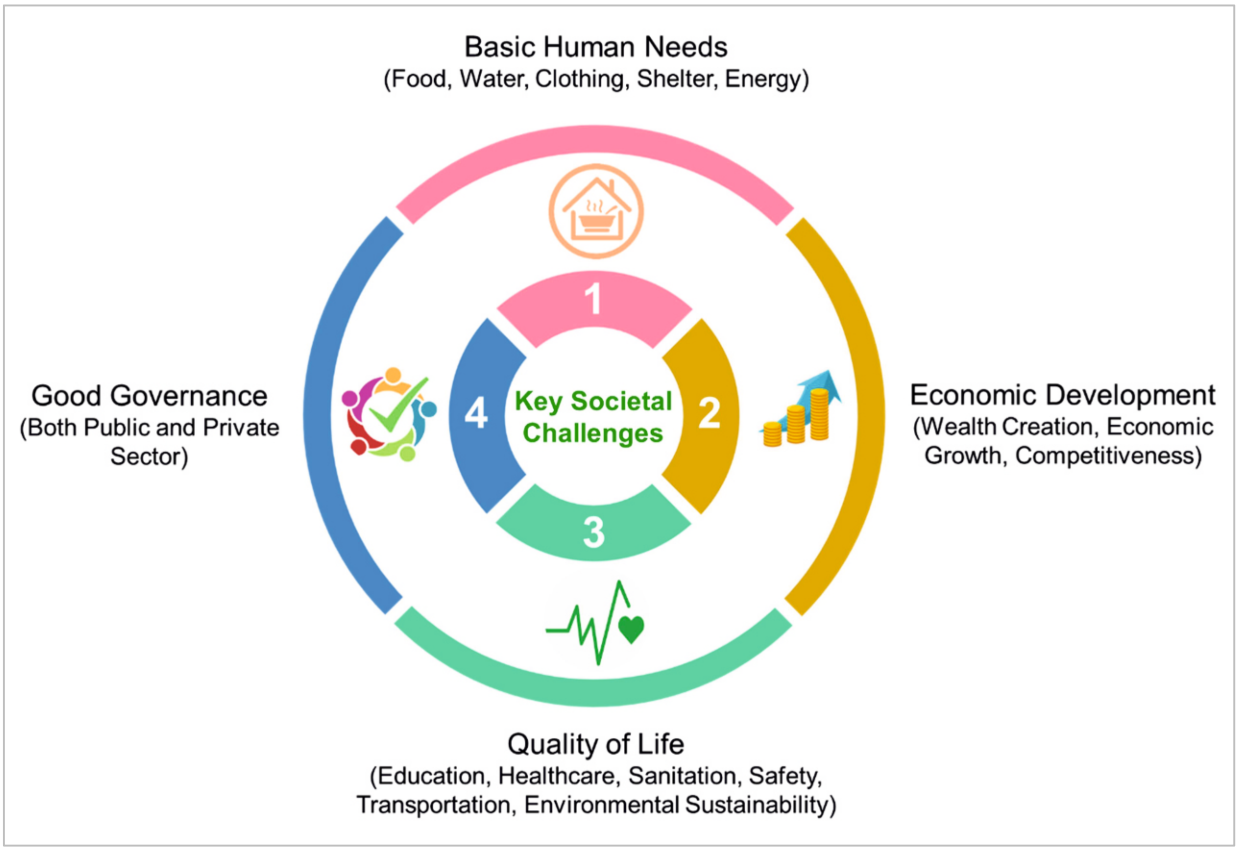


Figure 4: Key societal development challenges for science, technology and innovation in Pakistan[23]

[23] Tariq Bashir.2021. Evolution of national science, technology and innovation policies in Pakistan [submitted manuscript]

Digital technologies have advanced more rapidly than majority of the other technologies. All the digital technologies are directly linked to the availability of internet, therefore, access to internet is essential. The COVID-19 pandemic has compelled people, more than ever before, to use the internet for a wider range of activities like on-line education and work from home. The internet is a tool of unprecedented power; those not connected through the internet remain cutoff from most of the benefits of this new era and lag further behind.

Unfortunately, Pakistan has been ranked the lowest among South Asian countries in terms of access to the internet, as measured by the Inclusive Internet Index 2021 developed by the Economist Intelligence Unit Ltd., United Kingdom. The report on internet usage among 120 countries puts Pakistan at 90th place, in the bottom quartile of the index and second to last in the Asia region. Pakistan ranks lower in all the four pillars of the index, i.e., availability, affordability, relevance & readiness, however, the country ranks relatively higher in the affordability pillar due to improvements in the competitive environment and decrease in mobile phone costs.

2.1.1. Meeting Basic Human Needs

Basic human needs are generally defined as the minimal list of elements which human beings require, in order to fulfill basic requirements and achieve a decent life[24]. Traditionally, food (including water), clothing and shelter are considered as the basic human needs. However, in the present day, energy may also be treated as a basic need as it is hard to imagine life without it.

The concept of meeting basic human needs as a government policy is not new, and may even date back to the colonial era. However, the basic needs approach to development did not become a mainstream approach in development till the second half of the 20th century. During the 1970s, the idea of designing a development strategy that had meeting basic human needs as its main objective, including those of the poorest of the population, was originated, and very quickly became one of the major development approaches in the developing countries, including Pakistan. Though, the ILO report for the 1976 World Employment Conference defined basic needs in terms of food, clothing, housing, education, and public transportation[25], most of the developing countries stuck to the more popular notion of the basic human needs - food, clothing and shelter.

The basic needs strategy of development seemed to have faded away by the end of the 20th century, but it came back with a vengeance in the shape of the UN Millennium Development Goals (MDGs) in 2000, which focused to meet the needs of

---

[24] https://link.springer.com/referenceworkentry/10.1007%2F978-94-007-0753-5_150
[25] https://www.un.org/en/development/desa/policy/wess/wess_bg_papers/bp_wess2010_emmerij.pdf

the world's poorest. The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015 in the form of 17 Sustainable Development Goals (SDGs), also recognizes that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth.

In nutshell, meeting human basic needs of its people remains one of the primary responsibilities of the national governments, therefore, national efforts of technological development and innovation cannot ignore meeting these needs.

2.1.2. Achieving Rapid Economic Growth & Development

In the present day, technology is one of the key drivers of economic growth and development of countries. More advanced the available technology is, the more rapidly the economy can grow. Although, in the modern knowledge economies, innovation and technological development has gained prominence more than ever before, but the relation between technology and development is not new. A quick look at the history of human civilization indicates that every major step in the development of human civilization was associated with the advent of some kind of new technology. However, with the time, technology has become increasingly more important for wealth generation, competiveness, and economic growth and development. Technological advancements and innovation impact economy in many ways such as:

i. Technological progress leads to industrial expansion and diversification.

ii. Technological advancements and innovation contribute in overall profitability of a business through making production and service delivery more efficient.

iii. Technological advancement leads to increased labour specialization, making labour more efficient and skillful, and encouraging them to learn and invent resulting in lessening of time and money involved in production.

iv. Use of technology increases labor productivity, e.g., use of machinery in the agriculture sector results in a gigantic impact on labor productivity.

v. Technology makes accessing and utilizing the natural resources more effective benefiting businesses as well as national economy.

vi. Much higher production levels can be achieved with the use of technology resulting in diminishing cost of production and increase in profit.

vii. Use of latest technology in the production process enhances quality of products leading to higher margins of profit.

Technology and innovations have been largely responsible for rapid economic growth in the developed countries. A major part of the increased productivity in the developed countries is due to technological change. It has been estimated that about 2/3 of growth of the United States' economy can be attributed to technological change, while labour force and capital, collectively, account for $^{1}/_{3}$ of the growth. In the future, technology will become even more important for national competiveness and economic growth as the modern economies are rapidly becoming "economies of variety" rather than "economies of scale."

2.1.3. Enhancing Quality of Life

The term 'quality of life' is used in a wide range of contexts, ranging from international development to healthcare, and politics. Quality of life does not only include standard of living, determined by wealth and employment, but also the built environment, physical & mental health, and opportunities and facilities of education, safety & security, transportation, sanitation, clean environment, recreation & leisure time, as well as freedom and human rights. In other words, quality of life relates to the over-all well-being of citizens.

Technology and innovation can play a fundamental role in improving quality of life through interventions in the multiple dimensions of over-all well-being of citizens, such as:

i. Creation of employment opportunities suitable for the individual, in adequate quantity and quality, which are vital for income generation, and impact almost all other dimensions of quality of life.

ii. Maintenance and restoration of physical and mental health, which is essential part of the quality of life of citizens as it determines how far they can participate in all activities of life.

iii. Provision of physical safety and security while maintaining human dignity.

iv. Enhancing access to education and learning, which plays a pivotal role in the lives of citizens and is an important factor in determining how far they progress in life. Level and type of education and skills also determine the employment an individual will have.

v. Protection of nature and environment for reduced adverse impact on the health of individuals and the economic prosperity of societies due to air, water, land and noise pollution.

vi. Establishment and maintenance of trust between communication partners by appropriate information and free communication. The power of networks and social connections should not be underestimated when trying to measure the well-being of an individual, as they directly influence life satisfaction.

vii. Enhanced opportunities of citizen participation in public opinion forming processes and development of a community in which freedom, order, and justice have equal weight.

viii. Availability of efficient, reliable, faster and comfortable transportation for movement of humans, animals and goods.

ix. Provision of improved hygienic and sanitation facilities.

2.1.4. Improving Governance

The concept of "governance" has been around for a long time, however, it has been defined differently by different people. The difference in the definition or meaning of the governance arises from the context - the level of governance we are talking about. Conventionally, governance is associated with the government, and in this context, it is defined as the exercise of power or authority by political leaders for the well-being of their country’s citizens. However, the governance is not exercised only at the government level, it is also exercised at the lower levels, e.g., at the organizational level. When the governance is exercised at the organizational level, it can be defined as a phenomenon for implementation of policies and schemes in the organization - any governmental or non-governmental organization such as a private company, educational institute, law enforcement agency, or any other entity.

At the governmental level, good governance refers to the structures and processes that are designed to ensure accountability, transparency, responsiveness, rule of law, stability, equity and inclusiveness, empowerment, and broad-based participation of citizens. This denotes that good governance at the government level is mainly concerned with the deliverance of sound social, economic and developmental policies in an effective manner. While at the organizational level, it refers to a systematic approach that incorporates strategic planning, risk management and performance optimization. Independent of the governance level, good governance is concerned with effective services delivery in any public or private institution.

Good governance by the governments is needed for the efficient delivery of services to public, securing justice to all, empowerment of every individual including women and youth, ensuring sustainable development – meaning the development policies should not only be meant for catering the needs of current generation, but availability of natural resources to future generations should also be ensured.

Technological advancements are having a thriving impact on the delivery of good governance. Digital technologies are on the forefront of revolutionizing the concept of service delivery, e.g., train / bus ticketing systems, automated teller machines (ATMs) etc. Information and communication technologies (ICTs) such as cell phones, tablets, open data and social media etc., possibly have greater impact on delivery of good governance than other technology. ICTs may contribute in good governance in three basic ways:

Functional: ICTs make existing governance systems function through increasing information and feedback on how well they are working - usually in the field of service delivery

Instrumental: ICTs make existing governance systems work more effectively and efficiently through increasing transparency, accountability, getting people's contributions and giving them responsibilities - usually in service delivery, but also sometimes in objective-setting, planning and budgeting.

Transformative: ICTs change existing governance systems through changing rules of the game with the active public participation and accurate decision-making.

Policy Statement 1:	Through wider consultations, specific challenges under the key societal development challenges will be defined, and science, technology and innovation efforts will be directed to address these challenges on a regular and consistent basis.
Policy Statement 2:	National R&D infrastructure will be strengthened, through ensuring availability and proper utilization of latest equipment, to enhance its capacity to contribute in societal development.
Policy Statement 3:	Measures will be taken to increase the number of researchers per million population to bring it at par with the regional leaders.
Policy Statement 4:	Annual national R&D spending, as percent of GDP, will be enhanced up to the world average through various measures such as institution of a National R&D Fund, increasing share of industry in the total national R&D spending, etc.
Policy Statement 5:	Cross learnings across provinces will be encouraged to address developmental challenges and help in realizing Sustainable Development Goals.
Policy Statement 6:	S&T research culture will be reoriented, wherein, the performance of researchers will be assessed, recognized and rewarded on the basis of both academic achievements as well as socio-economic impact.
Policy Statement 7:	Access to internet will be enhanced across the country covering the aspects of availability, affordability, relevance and readiness.

Policy Statement 8:	An interface between media persons, scientists and science communicators will be developed for enhancing understanding of different stakeholders regarding the role of science, technology and innovation in the societal development, and uplifting status of scientists in the society.
Policy Statement 9:	Cyber security will be improved by building capacity, and by developing robust indigenous systems where data physically resides inside country's territorial boundaries and is protected by indigenous security mechanisms.

2.2. Smart Cities

Innovations in Science and Technology come together at a large scale to provide solutions at the societal level enabling the establishment and operations of "Smart Cities". Smart cities are entities which are self-aware, efficient, modern, and enable exchanges or transactions with their citizens through information technology-based management of all aspects of urban life. These include governance, security, transportation, energy, supplies, and services.

In Pakistan several initiatives have been taken such as the Safe City initiative, the electronic government initiative, etc. Whereas the former is security centric and the latter is government services (registries) centric, none of the initiatives provides a complete solution for Smart City implementation. Recently, the President of Pakistan has formed a committee for Smart City establishment, MoST has expressed a vision to transform up to 10 mid-tier cities into Smart Cities, and several private sector entities have sprung up to prepare for future public sector initiatives. These are welcome initiatives and must be coordinated for seamless execution. Ideally, their implementation be conducted in well-planned, coordinated, and phase-wise manner, with the phasing referring to several aspects such as technology integration, offering of services, size of city or convertible area, etc. Smart Cities are mega initiatives and have the potential to transform local industries as well as quality of living. Therefore, maximal localization has to be ensured.

Smart Cities have become an international buzzword in the last decade and significant strides have been taken viz-a-viz their development. At a global scale, the public sector, private sector, and NGOs have taken keen interest and prepared themselves for future Smart City revolutions. In the private sector alone, solutions for urban planning, transportation, data processing, energy management, etc. have been developed such as Huawei's data centre solutions, Schneider's Eco Struxure solutions, and more. A large amount of information on models, projects, products, solutions, etc. is available in the public domain and the optimized solutions may be used prior executing projects in Pakistan.

Policy Statement 10:	Ten cities will be transformed into “smart cities” in a phase-wise manner within the next ten years, by adopting the latest concepts of smart urban planning, technology integration, and service provision.

Chapter 3

Adopting 21st Century Approach to STI Governance and Management

CHAPTER 3

Adopting 21st Century Approach to STI Governance and Management

3.1. Scientific Advice to the Government

The importance of scientific advice to the government, in both "policy for science" and "science for policy" context, is gaining increasing prominence worldwide in government structures due to overarching and cross-sectoral nature of the science, technology and innovation activities. Many countries have established extended scientific advisory systems in order to integrate science, technology and innovation into all government departments. In the United Kingdom, post of the Government Chief Scientific Adviser (GCSA)[26] has been created, who reports to the Cabinet Secretary and to the Prime Minister, and thus provides independent advice on scientific issues at the highest levels of government. Most individual government departments in the UK also have their own Departmental Chief Scientific Adviser (DCSA)[27] for provision of advice on scientific matters related to the department. India has established office of the Principal Scientific Adviser (PSA) to the Prime Minister, which is led by the prominent scientist of the country. USA also has a post of Presidential Science Advisor, which the present government intends to elevate, for the first time in history, to be a member of the Cabinet[28].

For pragmatic and objective advice at the highest level, countries like India, United Kingdom, China, Japan and the United States, have also established scientific advisory bodies. Prime Minister's Science, Technology, and Innovation Advisory Council (PM-STIAC)[29] has been established in India to advise the Prime Minister and cabinet on matters related to science, technology and innovation. This Council also facilitates the Principal Scientific Adviser's Office to assess the status in specific science and technology domains, comprehend challenges in hand, formulate specific interventions, develop a futuristic roadmap and advise the Prime Minister accordingly.

In Japan, the Council for Science, Technology and Innovation (CSTI)[30] was established through the Act of Parliament in 2001 under the Cabinet Office to support the Prime Minister and his Cabinet. The Council provides a vision on science and technology as a whole in Japan, and is responsible for science and technology

---

[26] https://www.instituteforgovernment.org.uk/explainers/government-chief-scientific-adviser
[27] https://www.gov.uk/government/groups/chief-scientific-advisers
[28] https://news.mit.edu/2021/biden-taps-lander-zuber-science-posts-0115
[29] https://www.investindia.gov.in/pm-stiac
[30] https://www8.cao.go.jp/cstp/english/sipoverview.pdf

policies as well as for overall coordination at a position higher than individual ministries. Chinese Academy of Sciences (CSA)[31] has prominence in the Chinese

scientific advisory system. The central government of China give great importance to CSA, urging it, as a third-party organization, to fully play its role as a scientific advisor and further develop its capability and approach for consultation, and improve its organizational structure.

Policy Statement 11:	Institutions and mechanisms for scientific advice to the government at the highest level will be strengthened at the Federal as well as the Provincial level.

3.2. Appointment of STI Leaders

There are more than 80 science and technology (S&T) organizations - with many more sub-organizations in the country. It is assumed that these organizations would play their due role in the socio-economic development of the country. However, this can happen only if they are provided with adequate human and financial resources, and most importantly, are led by the "right leaders".

As per a Gallup report, the companies fail to select managers with the right talent more than 80% of the time[32]. This inference is based on the study in the private sector in the advance countries, where companies have less limitations of procedures, more freedom of choice, and selection authority may have to pay the price of a wrong selection as it may also be responsible for performance of the company. This indicates that how challenging a task of appointing appropriate heads of the organizations in the public sector organizations in the developing countries can be. It is also important to note that the S&T organizations are different than the other public sector agencies as well as business and commercial entities due to the complex nature of the STI activities, sensitivities involved in the management of creative manpower and need of making scientific research, technological development and innovation relevant to the society and economy. This makes management of the S&T organizations a highly challenging task for which personnel with specialized knowledge, skills, abilities and aptitude are required. The appointment of suitable heads of the S&T organizations become even more critical as they not only have to properly manage the organizations, their research portfolios, research groups and individual researchers but they also have to provide true leadership.

Generally, the selection of scientists for the posts of heads of the organizations is made on the basis of their scientific achievements, and management qualities are totally ignored or in rare cases generic managerial

[31] https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2828641
[32] https://www.gallup.com/workplace/231593/why-great-managers-rare.aspx

capabilities are assessed. However, relevancy of the qualifications and experience, specific requirements and leadership qualities in accordance with the mandate and functions of the concerned organization are more often than not or totally ignored. It is really inexplicable to note that the “eligibility and selection criteria” devised for the selection of heads of the S&T organizations generally makes the internal candidates unsuitable for the selection, while the external candidates who have never performed those functions, which they have to perform after selection, become the most suitable for selection. It is contrary to the fact that organizational candidates are the ones who generally have the most relevant experience, skills and capabilities- Gallup puts it as “the management talent exists in every company. It's often hiding in plain sight[33]”.

Policy Statement 12:	Appointment of “right STI leaders” in the S&T organizations will be ensured through putting in place appropriate mechanisms for determination and assessment of qualifications, knowledge, experience, skills, and aptitude in accordance with the specific mandate of the concerned organization.

3.3. Evidence-Based Decision-Making

The term evidence-based decision-making is being widely used these days to postulate a process of making decisions about a policy, programme, or practice that is grounded in the best available research, and empirical & relevant contextual evidence. It has been comprehensively defined as an approach that “helps people make well informed decisions about policies, programmes, and projects by putting the best available evidence from research at the heart of policy development and implementation”. This approach stands in contrast to opinion-based policy, which relies heavily on either the selective use of evidence or on the untested views of individuals or groups, often inspired by ideological standpoints, prejudices, or speculative conjecture[34]. With the time, the trend of opinion-based policy-making is being replaced by the evidence-based policy-making, which is more rigorous, and is based on rational approach that gathers, critically appraises and uses high quality research evidence to make informed decisions. This is happening because policy decisions, which are based on systematic evidence increase likelihood of achieving desired outcomes than those based on opinion.

In Pakistan, one of the main reasons for inconsistency in implementation and sustainability of policies at the national as well as at the institutional level is that the policy decisions are generally made based on the personal opinions and selective

[33] https://www.gallup.com/workplace/231593/why-great-managers-rare.aspx

[34] Davies P. (2004) ‘Is Evidence-based Government Possible?’ Jerry Lee Lecture, presented at the 4th Annual Campbell Collaboration Colloquium, Washington DC.

evidence rather than on ample factual evidence. Cultural traditions, time-related pressures and lack of data can be presented as the main reasons for lack of evidence-base decision-making in Pakistan. In order to promote evidence-based decision-making, the availability of relevant, accurate and reliable data is a prerequisite, which unfortunately is infrequent in Pakistan.

As far as STI data in Pakistan is concerned, Pakistan Council for Science and Technology (PCST), Pakistan Scientific and Technological Information Centre (PASTIC) and Higher Education Commission (HEC) are the main relevant organizations.

PCST has the responsibility to collect, update and maintain national STI statistical indicators to be utilized by the policy makers for formulation of national STI policies as well as by PCST itself for effectively performing its main role of STI policy advice to the government. PCST also has the responsibility to provide this information to UNESCO Institute of Statistics for inclusion in international publications and world-wide dissemination.

PASTIC's role is to collect scientific and technological information and disseminate it to the scientists, researchers, and engineers to facilitate them in their research, and remove duplicity of R&D effort and thus reduce wastage of scarce resources. It also assumes the role of providing scientific and technological information to the entrepreneurs, industrialists and general public in a way that is useful for them to derive socio-economic benefits from such information.

HEC is mandated to collect information and statistics on higher education and higher education institutions, which may be utilized for evaluation of performance of faculty members and institutions, allocation of funds, support linkages between institutions and industry, formulation of higher education policies, and determine priorities for higher education institutions for promoting socio-economic development of the country.

Prevalence of policy research is critical for evidence-based policy-making. The main goal of the national STI policies is to build a strong and self-reliant STI ecosystem, which is effectively working towards achievement of national developmental goals. The accomplishment of this goal requires a strong body of relevant knowledge, however, culture of STI policy research is not prevalent in Pakistan. In order to fill the gap, STI policy research by researchers and scholars both from public and private sector, need to be promoted.

Policy Statement 13: For ensuring evidence-based decision-making, relevant organizations will be strengthened to enhance their capabilities and expertise in data collection, storage and analysis in their respective domains.

Policy Statement 14:	National Science, Technology and Innovation Management Information System (STI-MIS), including a centralized data repository, will be established as a knowledge hub to support evidence-based decision-making in science, technology and innovation.
Policy Statement 15:	Programmes will be initiated to encourage STI policy research in the public policy institutes, S&T organizations, universities and industrial establishments to boost policy research on the issues concerning STI policy in the country, and build a network of STI policy researchers in Pakistan to strengthen knowledge base for evidence-based STI policy formulation.

3.4. Removing Disparities in Incentives for Doing Science

Brain drain of high quality manpower, due to lack of opportunities, career planning and inappropriate salary structures etc., is a continuous challenge for Pakistan. Our competent scientists are continuously inclined to move aboard due to financial incentives and liberal immigration policies for the highly qualified manpower of the countries like Canada, Australia, New Zealand, Germany, UK and USA. Moreover, Gulf region has become another significant sink for the quality scientific manpower.

At the same time, within Pakistan, competent S&T manpower is drifting away from its R&D related jobs through its employment on other positions offered by international organizations, NGOs and private sector organizations. It is also worth mentioning that many departments / organizations of the Federal Government have been allowed various additional allowances and incentives, which range from 100% to 200% of the basic pay. While the S&T organizations working under the Ministry of Science and Technology as well as provincial S&T organizations are not allowed any additional allowances or incentives at all.

To ameliorate the problem of brain-drain, due to economic reasons, in the past Government took the initiative by enhancing the salary and emoluments of scientists working in some S&T organizations like PAEC, NESCOM, PARC, and Higher Education sector. In some of the S&T organizations, heads are also being hired on Management Position Scales. However, in many S&T organizations, particularly in the S&T organizations working under the Ministry of Science and Technology and provincial S&T organizations, the salary structure remains irrationally low as compared to many other scientific and non-scientific government departments. Further, researchers in the many provincial S&T organizations are hired on BPS pay scales but on contract basis, with no chance of becoming permanent employees. Hence, recruitment and retention of technical manpower in S&T organizations is becoming a challenge.

There is a need to address this peculiar situation, where some scientists are paid more and some are paid less for doing work of similar nature and level, just because they work in the different organizations. This creates restlessness among scientists and negatively impacts the performance. Pays and privileges of scientists may be based on the qualifications and output, and not on the mere fact that they belong to different organizations.

Policy Statement 16:	Science and technology (S&T) organizations will be provided uniform service and salary structures as well as career development structures, eventually creating a single S&T cadre.

3.5. Revival of the National Commission for Science and Technology

The National Commission for Science & Technology (NCST) was established by the Government of Pakistan in 1984 as per recommendation of the Science and Technology Policy - 1984. The Commission is headed by the Prime Minister of Pakistan and is the apex decision making body that provides directions to the scientific and technological development of the nation. The Commission also provides leadership and guidance for the development of a strong and well-integrated S&T system directed towards welfare of the people, socio-economic development and security of Pakistan.

Implementation of the decisions of NCST is overseen by the Executive Committee of the National Commission for Science and Technology (ECNCST) chaired by the Federal Minister for Science and Technology with Deputy Chairman Planning Commission as its co-chairman. Pakistan Council for Science and Technology (PCST) is the secretariat of the Commission. NCST comprises 26 members mainly having representation of ex-officio members. Two prominent scientists / technologists and two leading / innovative industrialists are also nominated as member of the commission. These nominations are by name and are approved by the Prime Minister for a fixed tenure of two years. Chairman, PCST, supported by a small technical workforce, serves as the Secretary of the Commission.

The Commission is mandated to meet twice a year with the focus on the acceleration of scientific and technological capacity building for rapid and sustainable economic growth. The main functions of NCST includes coordination of inter-ministerial & inter-provincial S&T programmes; ensuring proper linkages of S&T effort with the production sector and development plans; consideration of major projects / programmes of S&T sector, and, half-yearly review of progress indicating not only the achievements but failures with reference to targets clearly identifying the bottle-necks.

In spite of being the apex S&T policy making body and being headed by the Prime Minister, it is very unfortunate that NCST has become a dormant forum. Although, the Commission is mandated to meet twice a year, its meeting has not been held for the last two decades. However, whenever its meetings have been held, they had a significant impact on the science and technology landscape of the country, which indicates its potential that needs to be tapped.

It is high time and the need of the hour to revitalize NCST, make it functional and reinforce its role as a forum for scientific and technological planning for the country. Pakistan Council for Science and Technology (PCST) as the Secretariat of NCST needs to be strengthened. An active and dynamic NCST would strongly be in a position to make short term to medium term to long term technological plans, develop and apply the emerging technologies on one hand and play its due role in timely cashing the global technological breakthroughs to boost the economic productivity of the country on the other hand.

Policy Statement 17:	National Commission for Science and Technology will be revived to provide leadership and guidance in the development of a strong and well-integrated STI ecosystem directed towards welfare of the people, socio-economic development and security of Pakistan.

3.6. Constitutional and Legal Cover for Science, Technology and Innovation

In today's world, science, technology and innovation are the key drivers of sustainable societal development. Technological revolutions and innovation underpin economic advances and improvements in health systems, environment, agriculture, transport, communication, education, infrastructure, etc. To reaffirm the critical importance of science, technology and innovation for economic, social and environmental development as well as for good governance, many countries have included it in their constitutions in one way or the other. For example, the Clause 2 of Section 45 of Chapter 3 (Principles Governing Economic and Social Policy) of Spanish Constitution states that "the public authorities shall promote science and scientific and technical research for the benefit of the general interest". While Section 8 of the Article 1 of the Constitution of the United States provides powers to the Congress "to promote the Progress of Science and useful Arts, by securing for limited times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries".

In the Constitution of South Korea, the Article 127 [Innovation, Standardization], Chapter IX: The Economy, states that "(i) The State strives to improve the national economy by developing science and technology, information and human resources, and encouraging innovation. (ii) The State establishes a system of national standards. (iii) The President may establish advisory organizations necessary to achieve the purpose referred to in Paragraph (i)".

The Sections 10, 11, 12, and 13 of Article XIV- Science and Technology, of the Constitution of Republic of Philippines state that;

- Science and technology are essential for national development and progress. The State shall give priority to research and development, invention, innovation, and their utilization; and to science and technology education, training, and services. It shall support indigenous, appropriate, and self-reliant scientific and technological capabilities, and their application to the country's productive systems and national life.
- The Congress may provide for incentives, including tax deductions, to encourage private participation in programmes of basic and applied scientific research. Scholarships, grants-in-aid, or other forms of incentives shall be provided to deserving science students, researchers, scientists, inventors, technologists, and specially gifted citizens.
- The State shall regulate the transfer and promote the adaptation of technology from all sources for the national benefit. It shall encourage the widest participation of private groups, local governments, and community-based organizations in the generation and utilization of science and technology.
- The State shall protect and secure the exclusive rights of scientists, inventors, artists, and other gifted citizens to their intellectual property and creations, particularly when beneficial to the people, for such period as may be provided by law.

The Clauses 4 and 13 of Article 3 (State Goals) of the Chapter I (General Principles) and Clause 7 of the Article 43 of the Chapter IV (Economy and Financial Affairs) of the Constitution of the Islamic Republic of Iran state that:

- Strengthening the spirit of inquiry, investigation, and innovation in all areas of science, technology, and culture, as well as Islamic studies, by establishing research centres and encouraging researchers.
- The attainment of self-sufficiency in scientific, technological, industrial, agricultural, and military domains, and other similar spheres.
- The utilization of science and technology, and the training of skilled personnel in accordance with the developmental needs of the country's economy.

In Pakistan, science and technology is a federal subject as per Fourth Schedule of the Constitution of Pakistan, however, it has not been mentioned in main body of the Constitution itself. In order to reflect that the State attaches high importance to science, technology and innovation for sustainable development of the country, it needs to be mentioned in the Constitution.

With the ever-increasing volume of national science, technology and innovation activities, encompassing all spheres of life, the need to establish fundamental guidelines and principles for the governments in promoting scientific, technological and innovation development to raise the standards of science, technology and innovation, and its application for sustainable national development and geographical security, STI laws have been enacted by many national governments throughout the world. Some examples from the developed as well as the developing countries are presented below:

i. The Science and Technology Basic Law, Japan

ii. The Science and Technology Act, UK

iii. Law of the People's Republic of China on Science and Technology Progress, China

iv. The Science, Technology and Innovation Act, Kenya

v. The Science and Technology Development Law, Myanmar

vi. Law on Science and Technology, Vietnam

A Science, Technology and Innovation Law may provide for organizations and individuals involved in scientific, technological and innovation activities as well as the organization of such activities. The law is not only critical for provision of legal and regulatory environments for scientific and technological developments but it will also regulate the ethical consequences of scientific research and new technologies.

Further, the law may define roles of the federal and provincial governments in promotion, development and application of science and technology. It can also prove valuable in ensuring sustainability of the STI policies, which is critical as the research and development activities require a reasonably longer period of time to create desired impact on the national socio-economic development.

Policy Statement 18: Science, technology and innovation will be included in the Constitution of Pakistan through a constitutional amendment, and a Science, Technology and Innovation Act will be promulgated to provide legal cover to such activities in the country.

Chapter 4

Invigorating Human Capital for Driving Innovation

Chapter 4

Invigorating Human Capital for Driving Innovation

The STI policy follows a comprehensive science, technology and innovation agenda, which requires a total complement of human capital or knowledge workers to move forward. It is well-understood that the societies that have invested in the knowledge and skills of their people have become the global economic leaders.

The OECD Future of Education and Skills 2030 project proposes OECD Learning Compass to describe three kinds of skills desired by 2030. These include cognitive and meta-cognitive skills (critical thinking, creative thinking, learning to learn and self-regulation); social and emotional skills (empathy, self-efficacy, responsibility, and collaboration); and practical and physical skills (utilizing new information and communication technology devices).

In addition, role of STI is mentioned fourteen times in the UN 2030 agenda as a tool for SDG implementation where focus is on development, transfer and dissemination of the STI to developing countries and to enhance their STI capacity to achieve SDGs across the four pillars. Therefore, to prepare the national pool of knowledge workers for the STI ecosystem, a holistic human capital development is mandatory where formal education begins from school to TEVT institute or university.

Scientists, technologists, researchers, entrepreneurs, businessmen, and technology managers play a great role in making the STI agenda functional. The regular upgrade in their knowledge and skills is of utmost importance in building the STI human resource of country. It has been discussed in the National Education Policy Framework (2018) that the existing education system of Pakistan is struggling with four challenges. Each one of these challenges is directly aligned with the national STI policy. The first challenge mentions “out of school children” with low and inequitable access resulting reduction in the availability of knowledge workers for the STI ecosystem. The second challenge mentions about absence of the “uniform education system” causing disparities in knowledge and skills of future STI human capital. The disparities are mentioned for learning English language and connecting religious concepts with science and society. The third challenge mentions “poor quality of education” mainly because of poor teaching quality resulting failure in transferring STEM knowledge and inculcating skills like creativity, responsibility, collaboration and ethical values and principles required by students of the STI ecosystem. The fourth challenge mentions weaknesses in “skills and higher education” due to poor relevance between teaching and research and weak linkages between universities and industries, which is very much required by the STI ecosystem in terms of harnessing commitment to the R&D for solving the national problems.

Policy Statement 19:	A holistic approach to human resource development will be adopted to develop a continuous pool of knowledge workers for the national STI ecosystem.
Policy Statement 20:	Qualified and skilled human resource in the identified emerging technologies will be produced as per requirements.

4.1. Human Resource Development

4.1.1. School Education

We are living in times where everyone is surrounded by technology and the products of science emanating every day. Public policy decisions are also dependent on scientific evidence. Even the natural world that surrounds us teaches us unlimited scientific concepts. Our children are growing up in an increasingly technologically and scientifically advanced world. As science is involved in students' everyday lives; it is, therefore, important that they are scientifically literate to be successful.

The teaching of scientific methods to students should be part of a student's academic career right from early schooling and it involves teaching them how to learn, how to think, how to solve problems and make informed decisions. In fact the scientific method starts when a student observes something and asks a question about it: what, how, why, where or when?

Many countries, particularly the developing countries, focus on post primary and high school level science education. However, many educators are of the view that science education should begin much earlier; teaching the young learners problem solving skills that will help them throughout their schooling and also engaging them in science from start.

Experts believe that children make up their minds about the science shortly after beginning school. Engaging young students with exciting material and experiences motivates them to learn and pursue the sciences throughout school.

UNESCO alarms about the steady decline of enrollment of young people in science and engineering and relates it to their poor access to the STEM curricula. Pakistan is also struggling in offering this access to its youth due to numerous challenges mentioned in National Education Policy Framework (2018). In the absence of a uniform education system in the country and with the looming threat of COVID-19, offering this access is even more challenging. This situation, however, requires state's interest and interventions towards standardizing and regularizing of the education system with revamped curricula, one that is blended with three skills proposed by the OECD Learning Compass. In addition, a disconnect between Al-Quranic teachings at Madrassah and Science teaching at public and private schools is widening further this gap of access to STEM Education. Today, huge literature endorses the connection between learning from Al-Quran and Science and even three skills proposed are very much present in the Islamic practices. Alongside, COVID-19 deprived most of our youth in public schools to learn even from the existing knowledge, however, a shift of private schools to online teaching save some of their precious time. Consequently, a call is needed for enough schools with adequate facilities of blended learning, enough teachers equipped with knowledge of STEM teaching resources such as project-based math & science units, visual ranking reasoning & showing evidence tools etc. and skills of online teaching and blended learning.

Policy Statement 21:	Cognitive skills of the children will be developed, by enhancing teaching skills of science teachers, modernizing syllabi and adopting novel teaching methods such as storytelling of scientific concepts, learning through playing, field trips, etc.
Policy Statement 22:	The concept of STEM education will be implemented in letter and spirit in the selected schools to be replicated at a larger scale.

4.1.2. Participation in International Student Assessment Systems

The prosperity of countries nowadays greatly depends on their human capital and the learning opportunities provided to their citizens throughout their lives. The governments are compelled to give incentives to individuals, economies and societies to raise levels of education, which has remained the driving force to improve the quality of educational services.

The programme for international student assessment was initiated by the Organization for Economic Cooperation and Development (OECD), an intergovernmental economic organization with 36 member countries to measure 15-year-olds' ability to use their knowledge and skills to meet real-life challenges. The programme for International Student Assessment produces comparable data on education policy and outcomes across countries. This programme is one of the examples of international assessment of students.

Generally, countries monitor student learning in order to gauge the performance of their education system and find out how well their education systems prepare students to meet the challenges of the future. This system is already in place in the country, however, comparative international analyses can extend and enrich the national picture by providing a larger context within which to interpret national results. It can also help the country to know about its relative strengths & weaknesses, monitor progress, and generate evidence to direct national policy for schools' curriculum, instructional efforts and for students' learning.

Participation of Pakistan in global education testing system will not only provide insights into the health of our education systems but also improve the higher order thinking skills of our students.

Policy Statement 23:	Efforts will be made and mechanism would be developed to ensure the participation of Pakistan in the global education testing systems.

4.1.3. Higher Education

Universities serve at the highest peak of learning and revamping science curricula for universities is, therefore, essential too. Science graduates may serve at educational institutions as scientists and researchers, at industries as innovation and operational managers or even establish their own businesses as entrepreneurs based on knowledge and skills they gather through higher education. Inculcation of skills related to ideation, invention, product design, prototype development, innovation, patent filing, business registration, entrepreneurship etc. are desired to be blended with the science curricula for sound STI ecosystem.

Higher education policies are gradually fostering the culture of entrepreneurship through the establishment of science parks and incubation centres, however, there is no proposal of teaching standard business model canvases to all the science graduates as a part of their curricula. Literature presents an advance teaching module based on the Lean Canvas for Invention (LCI), which allows science graduates to align their research with social problems and develop indigenous technologies to solve it. The LCI facilitates the process of creative & critical thinking and guide science graduates to convert their inventions to innovations. LCI gets directions from two other canvases, Business Model Canvas (BMC) and Bee-Star, for the establishment of their enterprises. Alongside, identification of potential economic sectors must also be embedded in the science curricula. At present, when STI ecosystem (Frame 1 – R&D and Frame 2 – Systems of Innovation and Entrepreneurship) is transforming towards its Frame 3 with focus on SDGs, the revamped SDGs and solution to problems based curricula can allow the science graduates to play their significant roles toward the national economy by creating knowledge, innovations and developing solutions for SDGs nationally & internationally.

SDGs (target 9) supports domestic technology development, research & innovation in developing countries and calls for universities to play their part in the Frame 3 of the STI ecosystem. The science curricula at universities can be revamped by translating global SDG agenda to national context and accordingly identifying the national challenges and proposing the social & technological innovations. Consequently, science graduates may develop, test and upscale the local solutions, which may be measured to show local progress to UN through appropriate indicators. The solution devised ultimately allows science graduates to become entrepreneurs.

Policy Statement 24:	Science education at the university level will be revamped to inspire science graduates to align their research with real-world social problems and development of their indigenous solutions.

4.1.4. "Industry-Ready" Human Resource

The human capital produced at school or university level functions as the input resource for existing industries and economic sectors. However, there is a mismatch between demand and supply of this workforce. The current training capacities are insufficient to offer industry ready HR in terms of number of qualified workforce and in terms of skills required by the market. To meet these shortcomings, National Technical and Vocational Education and Training Policy (2018) proposed eight objectives with target of training one million human capital annually. The policy also emphasizes on design and delivery of competence-based education and training programmes for concentrating on skills required to secure jobs. In addition, proposed establishment of National Vocational Qualification Framework (NVQF) Council is an added step towards establishing strong institutional linkages with industry and designing trainings that meet the market requirements. However, the policy overlooked the new sectors for economic growth based on emerging technologies like Artificial Intelligence (AI), Psych Technology, Robotic Process Automation (RPA) and Internet of Things (IoT) etc. having potential of replacing the human capital in the job market.

STI policy, therefore, focuses on upgrading the less skilled workforce to the skills required for managing the emerging technologies along with development of new business and economic models to keep this human capital as one of the players of the existing economy. For developing countries, nurturing of new dynamic economic sectors is proposed along with continuous commitment from all actors of the human pyramid and evaluation & implementation of the vertical STI policies along with the horizontal ones. The horizontal policies are proposed to be devised for all newly established economic sectors and the vertical policies to be devised distinctly for newly introduced specialized economic sectors. The new economic sectors may emerge by combining existing sectors and blending them with emerging technologies. For example, effectiveness of robotics in agriculture and utility of AI for teaching and services etc. The assessment for these sectors calls for mapping of existing human capital within country at all levels of education and proposes utilization of highly skilled human capital at universities for designing & delivering trainings for technical and vocational education.

Policy Statement 25:	Steps will be taken to produce “industry-ready” human resource equipped with entrepreneurial skills for industry and other economic sectors.

4.1.5. Encouraging Youth to Opt for Scientific Careers

The requirement of the society or business is not only technology but more importantly talent. Researchers inspire many of the ideas, aspirations and actions that contribute to the vitality of society and its capacity for creativity in this dynamic world. The prime function of leading-edge research is to develop new understanding and the creative people who incorporate it into society. It is, therefore, critical that the best intellects in each generation continue to be attracted to research careers, and are given every opportunity to grow in confidence, capacity, ambition and creativity.

Science, technology and innovation are the engine of welfare and development in a knowledge based economy. In a complex and fast-changing world, researchers can contribute to a better understanding of society and addressing its big challenges. In this context, new generations of researchers and scientists are key to Pakistan's future research and our vision of a knowledge based economy. There is a need to boost the attractiveness of scientific careers for young people, to support young researchers in their careers, foster their talent and offer them attractive career development opportunities. The overall aim is to create better conditions for young researchers not only in the higher education institutions but also in the R&D organizations and Industry.

Policy Statement 26:	New generation of scientists and researchers will be supported and promoted as the key drivers of socio-economic development by raising the attractiveness and prestige of scientific careers compared to non-scientific careers.

4.1.6. Enhancing Participation of Women in Science and Technology

Women, traditionally, have not been encouraged to embrace the learning of science at all levels of the educational system. This has created a lopsided picture of the relative proportions of women and men involved in the learning, teaching and practice of science, engineering, technology and related fields as compared to their male counterparts. The gender dimension of science and technology (S&T) has become an increasingly important issue globally in the recent decades.

The female participation in the higher education at Bachelors and Masters Levels in various fields of science and technology is low as compared to that of males in the country. The situation is no different at the MPhil and PhD level, where there is low enrollment of females. As per data of 2017, 31,743 females are enrolled in the MPhil level studies as compared to 45,757 males. Likewise, at the PhD level, there are 5,222 female students as compared to 7,912 male students. Lower female enrolment in the Science, Technology, Engineering and Mathematics (STEM) programmes at the educational level results in the lower number of female researchers in the R&D institutions.

However, it is encouraging to note that as per recent available data (2018), the percentage of female researchers in Pakistan has jumped from 30% (2007) to 39% in 2017. However, despite this progress, there is still a long way to achieve gender parity in science and technology. Initiatives on the sustained basis are required to increase the recruitment, retention and success of women in the science and technology sector. Many females are excluded from participation in science and technology due to lack of opportunities of education (at all levels), or other factors related to the prevailing social and cultural environment. Resultantly, women remain under-represented in most disciplines of science and technology. To rectify the situation, special incentives and motivation packages for female science students will be designed.

Policy Statement 27: Women will be encouraged to participate in science and technology at all levels of education and supported to opt for scientific research careers.

4.1.7. Promoting Science and Technology Culture

Science and technology culture may be loosely defined as the sum total of a society's concept and attitude towards science and technology as expressed in its beliefs, traditional customs and daily occupations. In this respect, the Pakistani society as a whole has to go a long way to embrace science and technology in its daily life. The lack of science and technology culture hampers the application of STI in industry and limits the benefits obtainable from other areas such as modern medicine. This is evidenced in the prevalence of the use of primitive tools in agriculture, fishing, blacksmithing, construction and other technology intensive occupations. At the social level, an explanation of natural phenomena is often sought in superstition.

Policy Statement 28: Science and technology oriented social culture, harmonized with our religious and traditional cultural values, will be promoted.

4.2. Human Resource Management and Planning

4.2.1. Establishment of the National Academy of STI Management and Planning

Adequate management of the R&D establishments, their research programmes / projects and harmonizing the efforts of researchers is critical for R&D organizations to play their role effectively in the socio-economic development of the country. Due to 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 top quality researchers cum highly qualified and specially trained managers are required.

Our researchers and scientists although very good in their own scientific disciplines but often lack managerial skills and capacities. One of the reasons for this is the lack of formal training opportunities in areas of STI management and administration. It is important to develop and upgrade “out-research” capabilities and skills of researchers, to enhance the impact of the R&D activities of socio-economic development.

There is a dire need for establishment of national level facilities to groom, nurture and prepare scientists / technologists / researchers, at all levels, for their future roles and responsibilities. This would also enhance their capabilities, skills and knowledge for aligning their research with the national research agenda, planning & managing administrative & financial aspects of research, selection of research projects keeping in view the socio-economic needs of the country, critical thinking & effective decision-making and refining their leadership skills. Specific training modules need to be developed for all levels of scientists, i.e., junior level, mid-level, senior level and executive level. Stakeholders other than the scientific community such as parliamentarians, bureaucrats, industrialists, media personnel, civil society representatives, etc. also needs to be sensitized about STI and its socio-economic importance.

Policy Statement 29: The National Academy of STI Management and Planning will be established for provision of in-service trainings to scientific community and science & technology orientation to other stakeholders of STI such as parliamentarians, bureaucrats, industrialists, media personnel, civil society representatives, etc.

4.2.2. Foresight for STI Human Resource for Future

The uninterrupted development of human resource in science and technology (S&T) and the capability building of relevant institutions must be at the top of the socio-economic development agenda, if Pakistan wants to develop, adapt, and introduce technological innovations with agility across various sectors. The role of S&T as a key driver of economic growth and development has long been recognized. The country’s S&T human resource have a pivotal role in the entire science, technology and innovation (STI) ecosystem.

In its 2016 Report on “The Future of Jobs: Employment, Skills and Workforce Strategy for the Fourth Revolution”, the World Economic Forum (WEF) suggests that disruptions across industries brought about by use of emerging technologies are reconfiguring business models and demanding various skills sets for the workforce by 2020.

In recent global and local scenarios, it is crucial for policy makers, educational institutions as well as current and future learners to anticipate the nature of future demands of the labor market arising from rapid changes in the world economy. Due to advancements in technologies at a rapid pace and introduction of new and emerging technologies obsoleting the old ones; countries that are not in the frontiers of STI will find it challenging to implement catch-ups and leapfrogs since innovation requires complementary factors (including strong institutions, human capital, hard and soft infrastructure) that may not be present. While extra spending on Research and Development (R&D) can be helpful, but spending alone is not enough to ensure that a country is ready for fourth or fifth industrial revolution.

Local studies conducted on the demands and supply of S&T workers in the country are scarce. Studies need to be conducted for projection of demands in the S&T human resource in the government, academia and industrial sectors, respectively, on a regular basis. The study will focus on the demand side in these sectors, particularly on the employment growth, potential investment in respective sectors, demand skills and hard-to-fill occupations (local and international), new jobs and their skills requirements, including diminishing jobs.

Policy Statement 30:	Future need assessment of STI human resource will be carried out focusing on the demand side of the S&T human resource mainly for catering the key societal development challenges.

Chapter 5

Transforming Knowledge into Product

CHAPTER 5

Transforming Knowledge into Product

The modern global economy is continuously evolving due to emergence of disruptive technologies, shorter product life-cycles and rising frequency in development of new products. The creation & possession of new knowledge and its effective exploitation for wealth creation is what determines the competitiveness of companies and nations worldwide. Countries are expected to benefit from their investments in generation of new knowledge, and making it a public good, which can be used by the entire economy leading to innovation and economic progress. Therefore, the current policy focuses on strengthening country's knowledge base and its application for product development. From an innovation policy perspective, support for new knowledge creation alone cannot achieve results in the absence of vehicles that delivers innovation, i.e., entrepreneurship. Therefore, the current policy also recognizes the importance of entrepreneurship and its pivotal role in balancing the complex knowledge-to-product equation, which will be focused in the next chapter.

5.1. Strengthening of Innovation Ecosystem

The existing innovation ecosystem of the country needs to be strengthened through upgradation of infrastructure, development of specialized human resource and promotion of a culture of innovation in the industry and academia.

When more actors start participating in an ecosystem, coherence and dynamism among different players is increased. This ultimately results into creation of economic value as well as welfare and well-being of society in the broader sense. From academic standpoint, a strong innovation ecosystem increases the likelihood of advancement in scientific breakthroughs or better understanding of people, society and nature. From industry point of view, a well-performing innovation ecosystem increases its willingness to invest in the ecosystem. Another important indicator of a strong innovation ecosystem is the production of successful startups and spin-off companies. In Pakistan, some successful startups have recently emerged, but so far there has been no example of conversion of these startups into a unicorn (billion dollar startup).

A strong innovation ecosystem is characterized by (i) a robust intellectual property rights (IPR) system that drives an innovator to protect his/her invention / innovation and earn recognition & royalties, (ii) a technology transfer system that facilitates commercialization of the research produced or creation of spin-off companies, and (iii) a specialized marketing & outreach system that projects, promotes and negotiates between the needs and demands of the academia and industry.

Nevertheless, an ideal innovation ecosystem is built on the strong foundation of basic and applied research. Major challenges in this regard are improving the quality of research produced and ensuring the research leads to innovation or economic and social impact. The key to address these challenges, is bridging the gap between academia and the industry by aligning the universities' supply with industry's demand, removing barriers for industry to access the relevant research groups in the universities and promoting understanding of each other's operations and processes, including time-lines. In this context, the policy recognizes the importance of making provisions for establishing and strengthening technology transfer structures, open innovation platforms, catapult centres, knowledge transfer networks and innovation funding schemes.

Policy Statement 31:	Funding will be enhanced for all stages of product development, i.e., research, patent filing, prototype development & technology transfer and commercialization.
Policy Statement 32:	National and institutional Intellectual Property policies will be formulated, and awareness of all stakeholders will be enhanced regarding importance of intellectual property rights, including geographical indicators of unique raw material & crops etc.

5.2. Enhancing Quintuple Linkages

The quintuple linkages envisaged in the policy aims to inculcate a sense of shared vision among all stakeholders in driving the economy of the nation while according due importance to the sustainability index. The expression "quintuple linkages" is derived from the idea of quintuple helix model of economy whose essential constituent is knowledge. Knowledge transcends across societal subsystems and converts into innovation and eventually transforms into knowledge economy. The model visualizes the collective interactions and exchanges of this knowledge by means of five sub-systems known as helices. The quintuple helix model consists on combination of academia (education system), industry (economy system), government (political system), society (social system) and environment (natural environment).

The concept of quintuple linkages advocates that mere conducting research and publishing its results does not guarantee creation of wealth or socio-economic impact. Technologies are developed and wealth is created by the collaboration between the academia and industry in an environment that is negotiated between the political, economic, social and environmental forces of a nation. Therefore, the nature and extent of linkages and interactions among all these stakeholders dictates the final outcome of the research. Recognizing the manifold dividends of these linkages and collaboration, the policy strongly advocates establishment of linkages among different elements of the quintuple helix for sustainable development.

Policy Statement 33:	Measures will be adopted to enhance quintuple helix linkages for full spectrum engagement of all elements of quintuple helix (i.e., academia, industry, government, society and environment), and in this regard appropriate forums will be established / strengthened.
Policy Statement 34:	Annual Science and Technology Expos will be organized on regular basis to encourage indigenous technology development and commercialization.

5.3. Promoting R&D and Innovation in Industry

Public funding of R&D as a tool of industrial policy remained a cornerstone of developed economies throughout the 1960s and 70s. The emergence of new technologies combined with the ideology of linking future success with investing in R&D, navigated the performance of industry of the developed world. By the 1980s specialized industries referred to as research-driven industries were widely accepted as 'crucial' ingredient for future industrialization and welfare.

For developing economies, like Pakistan, social returns on investment in R&D are higher than economic returns, whereas, short-term profit is what drives the private sector. Therefore, private sector is hesitant to invest in R&D in developing countries. It is the social returns and knowledge spill over through public funded R&D which eventually perpetuates the climate for private sector's participation in R&D. Industry in Pakistan had been facing constraints such as capital, human resource and knowledge due to increasingly tough business environment and cost of doing business. The industries had a disadvantage by venturing into R&D and innovation due to associated higher costs, less awareness and weak IPR regime. Therefore, the government aims to intervene to motivate the private sector towards R&D and innovation.

Public Private Partnerships in R&D need to be promoted and networks of investors, banks, private sector and academia need to be build. This will create an investment opportunity for investors, and a mechanism for researchers to share cost & risk. The government shall proactively facilitate the partnerships by establishing search databases, encouraging information disclosures of the market needs by utilizing networking intermediaries and by arranging events & exhibitions. The policy underscores the urgency of establishing centralized search database / repository for public use at present and for Artificial Intelligence / Machine Learning use in future.

Strengthening of IPR regime is another key area where government shall intervene to promote research & development in the Industry. The intellectual property system not only protects invention and provide incentive to the inventor but it also helps in diffusion of new knowledge, which perpetuates further innovations.

The policy aims to provide a conducive environment for the industry of Pakistan so that its competitiveness is improved.

Policy Statement 35:	Provisions will be created for industry to apply for research funding as primary applicants contingent upon involving academia and/or R&D organizations in research and intellectual property co-ownership.
Policy Statement 36:	Incentives, such as permission of consultancy, profit sharing, more freedom to interact and win projects etc., will be provided to the researchers in the industry related projects.

5.4. Formation of Research Groups

Some great breakthroughs of all times have emanated from research groups like the invention of transistor by Walter Brattain (Physicist), John Bardeen (Electrical Engineer) and William Shockley (Mining Engineer). There is an increasing trend and support for scientists and researchers of the same as well as different disciplines working together in a group setting to create new knowledge in specialized or interdisciplinary fields. The developed economies make the most out of their strong knowledge bases in order to stretch their boundaries in challenging traditional ways of thinking and finding new solutions to contemporary problems. Evidence suggests that teamwork enhances knowledge and learning of each member of the group resulting in more productive outcomes due to balancing of breadth against depth, basic against applied research directions and quantitative against qualitative approaches.

While the policy aims to promote formation of research groups in areas of national importance, it also acknowledges the importance of diverse teams having large social network in comparison to sole researchers in solicitation of research inputs and impacts of their research outputs as and when they emerge. More diverse formation of groups by engaging industry members / specialists in the focused research groups can trail-blaze the creation of such knowledge that can be leveraged into useful products. A well thought out strategy shall entail in mapping of areas of national importance as well as futuristic technologies before formation of specialized and focused research groups, which eventually will work towards creation of new knowledge and transformation of that knowledge in making products. For ensuring effectiveness of proposed research groups previous successful collaborations, diversity, clearly defined roles and goals, shared vision, collaboration readiness and provision of adequate administrative support measures will be taken into account.

Product development is a time-consuming and exhausting process that requires research and development of deep level in both the technical domain as well as the business domain (assessing the market needs). The process of product development involves ideation, concept development, testing, business analysis, market study, product development and then commercialization. While the research and development team may create new knowledge, its economic realization is only possible when experts of different domain sit together and negotiate the features of the product in question.

The policy recognizes the importance of research groups in contrast to individual persons and individual organizations for development of products as the debates over the idea, features and quality of the product are important for creativity. The distributed intelligence of the group also increases the chances of solving the problems more efficiently. The diversity of the group improves the techniques employed for research and widens the access to a greater number of facilities, labs and environments to reach to a better conclusion. Empirical data suggests a higher likelihood of commercialization of a product when ideas are generated and techniques for product developments are debated over.

Policy Statement 37: Establishment of multidisciplinary research groups, through pooling resource and expertise, will be encouraged and facilitated, to work on real-world socio-economic problems and their indigenous solutions as well as targeted product development.

5.5. Creating the Civil-Military R&D Interface

In many countries like the United States, the former Soviet Union, France, Britain, and China, defence R&D features prominently in their national innovation systems along with civil R&D. The countries which have established appropriate mechanisms for Civil-Military R&D collaboration have been successful in creating a synergistic effect on the development of technologies for the benefit of both civil and defence purposes.

The need to create an interface between these two important components of NIS, i.e., civilian and military R&D, was first felt by Vannevar Bush- advisor to the US President, who in his seminal report "Science- The Endless Frontier" in 1945, suggested the establishment of a Board, made up equally of scientists and military men, to take decisions regarding the classified scientific information for its declassification and release for publication. The "Board to Control Release" suggested in that report, can be stated as the first Civil-Military R&D interface. It is generally believed that the United States' dominance of high technology markets in the post-World War-II era was due to the cross-subsidization of its civilian technology by investments in military R&D. Aircraft design, space technology, nuclear power, and solid-state electronics can be presented as examples of the areas that benefitted from large-scale military spending, either for R&D or procurement or both.

In the UK , a series of reports during the 1980s, including the 1983 Maddocks Report to the Electronics Economic Development Council, the 1986 report of the Council for Science and Society, and the 1989 report by the Cabinet Office's Advisory Council on Science and Technology (ACOST), expressed concern at the limited civil benefits obtained from defense R&D spending. These reports recognized that the national economic benefits should be obtained from exploiting the synergy between the military and civil sectors.

China has created the Commission of Science, Technology and Industry for National Defense (COSTIND) in 1982 to speed up the defence industry's integration into the civil and commercial worlds. Under civil-military integration policy of China, civil-military research cooperation was channelized into several targeted areas, including biotechnology, energy, IT, spaceflight, new materials, and oceanography. Since late 1990s, the key goals of the Chinese defence R&D reforms, *inter alia*, include bringing defence R&D system closer to the rest of the national innovation system, and maintaining close linkages with universities and civilian research institutes. China has also established a Civil–Military Integration Promotion Department (CMIPD) under the Ministry of Industry and Information Technology.

The former Soviet Union, France, and Britain also pursued national policies based on investment in defence related technologies. In fact, many countries have aligned and enunciated clear long term strategies for developing their civil and military R&D systems in unison.

With the time, Pakistan has developed a significant capacity in the defence R&D, and has a noticeable defence R&D establishment, therefore, it is the time to enhance collaboration between the civil and military R&D for larger national security as well as socio-economic benefits. Further, geographical location of Pakistan and geopolitical situation in the region demands that Pakistan must establish a strong collaboration between the civil and military R&D setups. There are many fields in the defence industry for R&D, which can enhance national security and also earn socio-economic benefits. These include ship building, ship breaking, oceanography, fishing, mineral exploration and weapons & sensors development. In parallel, already established R&D setups in defence can provide opportunities and requirements to civil setups for larger national security interests. Therefore, it is the time to enhance collaboration between the civil and military R&D setups to ensure national security and earn socio-economic benefits. A right step towards achievement of this goal would be the creation of a proper Civil-Military R&D interface ensuring a win-win situation for all the stakeholders, i.e., military, civilian organizations and industry.

Creation of an interlinked forum involving Ministry of Science & Technology, Ministry of Planning, Development & Special Initiatives, Ministry of Defence Production and Defence R&D organizations is therefore desired. Goal should be to bridge gaps between civil and defence sectors and develop fusion strategies under a unified operational model. The forum may be utilized to integrate efforts of civil, military, and other public and private sector academic and R&D institutions to undertake projects of national importance, deliberate and identify core areas for civil-military R&D cooperation, propose projects having socio-economic benefits using civil-led or military-led technologies, identification of constraints in establishing meaningful civil-military collaboration

In the absence of any centralized body at national level in the past, to steer R&D efforts involving civilian and defence sectors, most of the initiatives once taken fizzled out due to lack of ownership focus and budgetary constraints. Therefore, establishment of a high power body to provide policy guidance and oversee operationalization from conception to implementation is of critical importance.

Policy Statement 38:	A national framework of integrated civil-military R&D cooperation will be established including a National Civil-Military R&D Cooperation Board.

Chapter 6

Promoting Technology based Innovation and Entrepreneurship

CHAPTER 6

Promoting Technology based Innovation and Entrepreneurship

Technology based innovation and entrepreneurship is the bed-rock of an STI policy in today's era. It is an endeavor that assembles and deploys specialized individuals and heterogeneous assets to create and capture value (competitive advantage). This value is generated by the collaborative experimentation between the academia and industry to create new products, assets and attributes, which are intricately related to advances in scientific and technological knowledge.

Technology based entrepreneurship is a vehicle that facilitates prosperity in individuals, firms, regions, and nations. Both innovation and entrepreneurship are inter-dependent because both are concerned with creation and capturing of value. Technology entrepreneurship applies to any firm with projects that rely on advances of S&T, while the innovation view applies to those industries that are continuously successful. Innovation is the dominant view in the strategic management that links its performance to its resources, capabilities, dynamic capabilities and its core competencies. The policy aims to inculcate and promote the culture of technology based innovation and entrepreneurship in the country.

6.1. Changing Perceptions of Risk

In Pakistan due to limited opportunities for employment and investment, majority of families follow selected routes for future employment and investment. The higher scoring students almost always are coaxed into choosing the pre-engineering and pre-medical routes, with information technology, accounting, law, etc. being secondary choices. Similarly, in the latter (selection of investment options), a large majority of families almost always proceed for investments in property or precious metals. All of these choices represent a "safe" route where potential for loss is avoided. However, with the notion of insulation, the possibility to achieve great and rapid wealth also diminish. Likewise, the risk averse route reduces the circulation of wealth in society leading to stagnation.

In order to address the above mentioned issue, well-planned and massive awareness campaigns are required. These campaigns may focus on the Islamic perspective of entrepreneurship & circulation of money, glorification of national and international success stories & role models, and encouraging entrepreneurship from childhood. Pakistani entrepreneurs may be invited to speak in television shows, featured in documentaries, awarded national medals, and also invited to address relevant occasions.

Policy Statement 39:	Social interaction of educated youth with entrepreneurial role models will be increased to change their perceptions of risk while creating startups.

6.2. Inculcating Entrepreneurial Skills

Developing relevant skills and mind-set among the graduates and young researchers is of paramount importance to the country. There is a need to strike the right balance between inputs and outputs of the STI ecosystem by imbibing the right skill-set in the graduates being produced by the system so that they can give back to the ecosystem. While there has been an exponential increase in tertiary education but little progress has been made on improvement in competencies and relevant skills. The critical skills shall include management, communications, traditional research skills and more importantly collaborative working skills. In addition to above, mentoring and mentoring networks are extremely valuable resource that need to be organized and institutionalized.

Entrepreneurial education is a global practice, which not only imparts training in starting and operating businesses but also provides critical skills such as market research, problem identification and solution, planning, speaking concisely and remaining focused, etc. Crucial life skills are also gained including collaboration, creativity, grit, and dealing with an uncertain situation.

In Pakistan, entrepreneurship is taught at the tertiary education (university) level; however, recent trends in North America and Europe point towards an even earlier education – students in secondary education (high school) level are also being taught entrepreneurship. Experts point to the fact that attaining basic business sense does not require higher education, and moreover, the structure of higher education is such that candidates are inherently biased towards job seeking by the time they are nearing the completion of a four-year degree programme. Moreover, many top business leaders today have not completed a four-year degree programme, yet this shortcoming did not come in the way of being tremendously successful in their entrepreneurial pursuits. Therefore, entrepreneurial education should be started as early as possible.

While formal training and coursework on entrepreneurship may continue as part of secondary and tertiary curriculum, practicums and skills training is necessary for immersive experiences and practical problem solving. Internship programmes for placing students in industry may be amended to focus on the startup and small and medium enterprise (SME) sector, as much as possible. This will enable the candidates to break ice with the oftentimes overwhelming concept of growing one's own business and conducting entrepreneurship independently. Additionally, skills training via technology focused boot camps may not only increase the chances for employment, it may also enable one to work independently. Indeed many of the skills taught in boot camps (such as full stack programming, data science, business intelligence, digital marketing, cybersecurity, project management, product management, etc.) are critical in operating one's own business. The government has recently started the *Kamyab Jawan* programme, which contains a "boot camp vertical" with the National Skills University (NSU) and National Vocational and Technical Training Commission (NAVTTC). This programme may continue, however, greater coordination, linkages with international certifications, and better employment seeking opportunities are required to be enhanced.

According to the Online Labour Index (OLI) published by the Oxford Internet Institute (OII) in 2017, Pakistan is the fourth most popular country for freelancing, with the priority focus being on Software Development and Technology. The Punjab Information Technology Board (PITB) estimates that USD 500 Million is earned annually via freelancing services; however, the Ministry of IT & Telecom (MoITT) opines that the actual figure could be much larger and can be reported in the true sense when a framework for e-Commerce is implemented and backed by the state. Freelancing has not only been identified as an excellent source of foreign exchange; however, it has also been identified as a route for increasing employment in the country. The MoITT has launched the DigiSkills programme in coordination with Virtual University (VU) and also the National Freelance Training Programme (NFTP) in coordination with PITB. These programmes focus on short courses like Creative Writing, AutoCAD, e-Commerce Management, Digital Marketing, Search Engine Optimization (SEO), etc. It is imperative that these trainings focus on the practical elements and hand-hold their trainees towards independent freelance "jobs" enabling them to start earning.

Policy Statement 40:	Entrepreneurship will be taught, starting from graduation level, to students of all "science and technology degrees", especially engineering and technology students, while training and facilitation will be made available for the budding freelancers in technology-based businesses.
Policy Statement 41:	Academicians' understanding of business world will be enhanced through trainings, academia-industry immersion programmes and market intelligence exercises.

6.3. Support for Technology & Innovation based Startups

Today, the people in the age of 20s and 30s are growing up in a radically different world than it was experienced by the preceding generation. In a radically globalized culture of setting-up one's own startup company instead of working for someone else, the country's new STI policy expedites mechanisms & measures to create a suitable environment for technology and innovation based startups to grow. The number of new startups, the fund raising activities, the initiatives at the level of universities and future outlook of the startup industry of Pakistan gives a positive impression but creation of culture of entrepreneurship by developing confidence in the minds of the youth still remains the major challenge for the government.

The policy reiterates the need for intervention by the government in providing support in ease of doing business, expanding funding opportunities by development of Venture Capitalist & Angel funds, promoting entrepreneurial culture by popularizing STI at the grass-root level through media & other communication channels, influencing the market dynamics in favour of innovation & technology based startups by startup friendly regulations and adequate funding for development of supporting infrastructure.

6.3.1. Incubators

Pakistan has accumulated nearly two decades of experience in setting up incubators and at present, there are at least 25 incubators in the country and over 80 co-working spaces. Incubators in Pakistan can be categorized into three types, public sector, private sector, and university-based.

The public sector incubators include the National Incubation Centres (NICs) setup by the MoITT constituent IGNITE (formerly ICT R&D Fund) in the federal and provincial capitals. MoITT has recently announced the NIC Expansion Plan with 11x new NICs to be added to the existing five in tier-2 and tier-3 cities. Besides NICs, Pakistan Software Houses Association (PASHA) has formed The NEST I/O, PITB has formed the Plan9, etc. The private sector has formed several incubators and accelerators including Telenor's Velocity, NETSOL's NSPIRE, Arpatech's Hatchery, Aptech's Tecube, Invest2Innovate, and an incubator by Microsoft. Finally, there are a number of incubators in academia including TechOne in NUST, Centre for Entrepreneurship in LUMS, CINETIC in NED-UET, CED in IBA, and incubators in GIKI, KIET, etc. Academic incubators are also known as Business Incubation Centres (BICs) and are governed by the Higher Education Commission (HEC) BIC Policy 2021.

The above incubators provide a variety of services including Stipend, Workspace, Networking, Mentorship, Business Development Guidance, Legal Assistance, etc. However, an association of incubators would be very helpful as these would provide information and share best practices. Similarly, incubator generations and services ranking should be made readily available. Many incubators also provide access to funding networks and venture capital funds – it would be ideal to have a known mechanism so that budding entrepreneurs could focus on developing their technology and services rather than worrying about funding channels. International models may be followed, e.g., University of California Berkeley takes 5% equity in exchange for USD 100,000 investment.

Policy Statement 42:	Network of National Incubation Centres (NICs) / Business Incubation Centres (BICs), in all sectors of economy, will be expanded and strengthened in both the public and private sectors.
Policy Statement 43:	Support will be provided to startups in priority emerging technologies meeting key societal development challenges, especially those which would be involved in R&D and commercialization of the products in collaboration with universities and government R&D organizations.

6.3.2. Access to Networks and Funding

As indicated in the previous section, a vibrant startup and SME support ecosystem includes services such as connecting to professional networks and assistance in arranging various levels of funding. The professional networks assist in various forms of guidance, dealing with growth plans, navigating regulatory channels, and connecting to potential investors. The funding access support includes assistance with obtaining seed funding, angel investments, tapping local and foreign funding opportunities, and finally venture capital funds.

Akin to any professional field, retaining the knowledge gained by the practitioners within the local ecosystem is critical to the success and growth of the ecosystem. In this case, there is a dearth of serial entrepreneurs who have been successful with their first startups and invested funds back into the system. Similarly, there is a shortage of angel investors who provide the necessary funding to reach a critical stage. The regulatory environment is still reacting to the concept of venture capital cycles and enabling timely exit and repatriation of profits. In such a scenario, public and private incubators in Pakistan would do well to create angel networks and tap the Pakistani diaspora, who would likely be less skeptical while viewing investments in Pakistani startups.

Venture capital (VC) funding is the stage which succeeds the early stages of obtaining public grants, obtaining angel investments and seed capital, etc. and is provided to rapidly scale-up operations with the intention that a profitable venture will provide a healthy dividend and an exit opportunity to the investors. VC funding is explicitly done in proven businesses (looking for expansion) with an interest in obtaining equity, profit, and exit to be able to invest elsewhere. Therefore, ease of bringing investments, transparency, and ease in repatriation of principal and profits, along with adequate facilitation, are key to enabling the Pakistani market to tap VC funds. In 2020 alone, over USD 73 Billion were invested globally by VC funds in over 3300 business deals; however, the share of VC funding in Pakistan was less than 0.1% of global volume (USD 50-80 Million). Many successful Pakistani startups register in foreign countries in order to raise funds, depriving the country of numerous benefits.

Addressing the above requirement in a timely manner is imperative. VC funding in Pakistan, has recovered and witnessed an uptick in 2021, which indicates that there is potential for rapid growth and maturity of businesses. According to *MAGNiTT*, Pakistan attracted VC funds worth USD 81 Million in 2015, USD 97 Million in 2018 (21 deals), and USD 39 Million in 2019 (31 deals). *Pakistan Today* quotes a higher figure of USD 48 Million for 2019, and USD 66 Million for 2020. However, the biggest upsurge has been witnessed in first three quarters of 2021 where USD 278 Million has been raised by Pakistani startups according to *Invest2Innovate Insights*. Nevertheless, the per capita VC funds available to Pakistani startups are still significantly less compared to neighbors India and Bangladesh, according to a *Mckinsey* report on unlocking entrepreneurship in Pakistan. In addition to an enabling regulatory environment, the foreign office, technology networks, and ministries related to science and technology, IT & telecom, and other governmental bodies must come together to continue attracting these funds, which promise rapid job and wealth creation. Similarly, local public – private VC funds must be created so that companies can increase in maturity and as an impetus for international VC funds akin to successful international programmes, which revolutionized the national tech ecosystems within a few years. The *Jiddat Fund* of Pakistan is still in the feasibility study stage despite being announced in 2019.

Policy Statement 44:	Funding support will be provided through establishment of Venture Capital Funds, creation of Angel Networks, outreach to the Pakistani expatriate community, etc.

6.3.3. Tax Incentives and Risk Mitigation

Providing a nurturing environment to entrepreneurs will pay large dividends at the national level as these entities take care of job creation, attract foreign direct investment, spur tremendous amount of economic activity, and ultimately lead to payment of greater taxes. However, to start off, a facilitator tax regime and loan regime is necessary. In 2017, the Federal Board of Revenue (FBR) launched a three-year tax exemption scheme for tech related startups registered with the Pakistan Software Export Board (PSEB). Such schemes may be continued and expanded. Similarly, in 2020, house construction loans have been extended to 20-year timeframes for the first time in Pakistan’s history. Such liberal loan regimes may be considered for the technology sector as well. According to a *Mckinsey* report, quoting from State Bank of Pakistan (SBP) records, only 188,000 SME loans were found to be outstanding on bank books whereas at least 3.2 Million SMEs exist in Pakistan. This indicates a huge private sector financing gap not been met by the formal sector.

According to the World Bank Findex survey, approximately 100 Million Pakistani adults do not have access to formal financial services. This represents 5% of the global unbanked population. Whereas, the FinTech sector is rapidly growing in Pakistan trying to fill this gap; however, the pace needs to be enhanced if a burgeoning and young population is to be served. Similarly, microfinance loans and transaction tools are required. The SBP has recently issued over a dozen electronic money institution (EMI) licenses and it is hoped that an upsurge in financial services will be witnessed in the next 1-2 years. Similarly, insurance products and risk reduction programmes may be introduced to encourage entrepreneurship, for example, individuals desirous of starting their own ventures, and bearing a well-defended business proposal, may be allowed to take 6-12 months off their work (extendable once) for growing a business. If successful, a job seeker would be converted to a job creator.

Policy Statement 45:	Tax exemptions, loans and insurance facilities will be made available for the startups.

6.4. Tech Clusters, S&T Parks and Special Technology Zones

6.4.1. Tech Clusters

After the independence of Pakistan, one of the earliest initiatives of the government was to focus on industrialization. The Pakistan Industrial Development Corporation (PIDC) was formed in 1952, followed by issuance of an Industrial Policy focused on import substitution and export promotion. The PIDC played an important role in establishment of industrial units; however, the separation of East Pakistan, nationalization drive, and other inconsistencies in policies translated to a less than desirable outcome. Industrial Estates were formed with provisions for infrastructure, supply of utilities, and facilitation centres; however, there were relatively limited liberal policies viz-a-viz taxation and customs.

Over time, several industrial estates and clusters formed across Pakistan including surgical goods and sports goods clusters in Sialkot, electrical and ceramic clusters in Gujrat, electrical and tannery clusters in Gujranwala, garments clusters in Faisalabad, marble cluster in Attock area, etc. These clusters have provided significant employment opportunities and also contributed to export proceeds; however, there is a dire need for their modernization. These clusters generally do not contribute to innovation and rely on one (or few) legacy products. Furthermore, the high rate of corporate taxation, complex taxation processes, dearth of utilities (electricity, gas, etc.) in the recent past, coupled with the attractive policies in neighboring countries (e.g., Bangladesh) have contributed to a premature deindustrialization of Pakistan. The share of manufacturing has slipped from 17% to 13% in the past five years and this trend must be reversed.

The industrial estates and clusters require urgent revival and therefore various steps would be required on a war footing. These steps include rationalization of taxes, mapping of industries and their degree of innovation, incentives for modernization and innovation, incentives for export promotion, and a unified framework for dealing with industrial estates and zones. The various chambers of commerce (e.g., FPCCI, ICCI, LCCI, SCCI, KCCI), industrial associations (e.g., SITE) and business councils (e.g., PBC) would have to be engaged proactively in order to revive the industrial estates, increase the share of manufacturing in GDP (to 20% by 2025), and increasing the share of Pakistan in global exports (to 0.25% or USD 40 Billion by 2025).

Policy Statement 46:	Growth of technology based SME clusters will be supported with incentives for modernization and tech enablement.

6.4.2. S&T Parks and Special Technology Zones

The importance of the high-tech industry in transforming the knowledge ecosystem, rapid job creation, and rapid wealth creation is well known. Therefore, various national governments globally have provided liberal incentives to the high-tech industry. Pakistan too has rolled out a number of policies to support the high-tech industry including the IT Policy 2013, Digital Pakistan Policy 2018, Electric Vehicles Policy 2020, and Mobile Device Manufacturing Policy 2020, etc. Whereas these policies address manufacturing, services, and related aspects; however, they are fundamentally sectoral in nature. Therefore, there is a need to look at high-tech industries holistically.

Recently, the government of Pakistan has promulgated the Special Technology Zones Authority (STZA) Act 2021, which focuses on the high-tech sector in a holistic manner. The ordinance provides special powers and hitherto unprecedented incentives to attract the high-tech sector and enable their growth. The authority has recently been formed to manage the creation of these special technology zones across the country and facilitate and regulate them. These zones may contain a plurality of science and technology parks (STPs), production units, software houses, R&D units, universities, and allied services. This initiative is in line with best international practices, which have led to the development of technology zones in China, South Korea, Malaysia, etc., and should be supported. Besides focusing on the urban areas, the nature of the technology sector is such that, with a little effort, the second and third tier cities as well as rural areas can be transformed.

Prior to the Special Technology Zones (STZs), the Special Economic Zones (SEZs) were created. These SEZs were administered according to the SEZ Act of 2012 (revised in 2016) and dealt with SEZs across the country. The Faisalabad SEZ (FIEDMC) is an example of a very successful SEZ with production units of motor vehicles, chemicals, fast moving consumer goods (FMCGs), etc. STZs are focused on the synergies of the entities in a technology innovation ecosystem (enterprises, academia, government, society) and are therefore unlike SEZs where highly qualified workforce is required in a considerably smaller number. However, some of the key differentiating factors between STZs and SEZs were the greater focus on the high-tech sector, technology transfer, R&D, and academia-industry linkages in STZs. Additionally, STZs have greater incentives in terms of income tax, customs duties, ease of imports, and repatriation of profits, etc. for a longer duration. At a national level, both STZs and SEZs are beneficial to the nation and the parallel streams (or tracks) may continue as this differentiation is ultimately beneficial for longer term transformation of Pakistani industry.

While SEZs and STZs are developed across the country, various government-to-government agreements may be harnessed for their rapid and thematic growth. For example, one of the aims of the China-Pakistan Economic Corridor Authority (CPECA) is to enable the industrialization of Pakistan through shifting of industries from China to Pakistan. As part of this plan, various SEZs across Pakistan will house Chinese industries introduced through CPECA. This has already been agreed in the cases of Faisalabad SEZ, Rashakai SEZ, etc. In similar fashion, the neglected sectors (thematic areas) of Pakistan can be grown through government-to-government agreements for STZ and SEZ development. Priority sectors may include vaccine development and pharmaceuticals, medical devices, information technology and electronics and communications systems, automobiles and aerospace technologies, food processing and packaging, etc.

Policy Statement 47:	Development of Special Technology Zones (STZs) will be promoted and facilitated across the country, especially in SEZs under CPEC and under-developed areas.
Policy Statement 48:	Five universities will be selected, initially, to establish technology parks in their close proximity, each targeting a specific sector of economy, e.g., IT, agriculture, energy, textile etc., (attracting national and international industry in the Park) to enhance product development in those areas.

6.5. Quality and Standards

Development of a new technology or a technology-based product does not guarantee that it is of good quality, meets required specification and is eco-friendly. As more and more technologies enter the market the need for quality assurance and standardization increases. Standardization and quality are closely inter-linked and they can influence the industry structure and can affect both the innovation and technology diffusion.

Standards are developed to maintain quality, specify acceptable products or service delivery along one or more dimensions such as functional levels, performance variations, service life-time, efficiency, safety and environmental impacts. Over a technology's life-cycle, standardization can affect economic efficiency. The effects of standardization can both be positive or negative. On one hand standardization can increase efficiency (and quality) within a technology life cycle but it also prolongs existing life-cycles to an excessive degree that it can be over-run by the next innovation life-cycle thus making it a hurdle in a rapidly changing technological landscape. The policy while underscoring the importance of standardization, aims to maintain a balance between market dynamics and product quality to facilitate a transaction that favours both the buyer and the seller of the technology.

Provisions shall be made to ensure that the public funded technology development objective is combined with the standardization exercise. This will facilitate the standardization of the key product element at an early point of technology life-cycle. The government R&D shall establish and demonstrate a back-bone infrastructure, which shall induce private sector R&D investment in standards to enable effective use of the infrastructure.

The policy supports and makes sufficient provision in strengthening institutions that are mandated to ensure standardization, quality assurance and environmental considerations by providing them with human & financial resources, capacity building by imparting training and infrastructure development so that an effective enforcement of standardization can be made and quality can be ensured as a corollary.

Policy Statement 49: Quality and Standards infrastructure will be strengthened to improve quality of products leading to import substitution on the one hand and export enhancement on the other hand.

6.6. Accreditation

An important aspiration for developing economies like Pakistan in the field of accreditation is not simply to keep-up with changing technological trends, but to become leaders and technological innovators going down the line. The policy aims to set the national direction towards product development and export competitiveness of the products being produced (or potentially produced in future) in Pakistan. The policy defines the future course of action for the country to become a globally integrated technology player that has the access to complex global competitive markets.

The policy acknowledges and attaches due importance to accreditation to generate cross-border confidence in product standards necessary to enable international trade. The policy sets the directions for national accreditation organizations and agencies to conform to internationally recognized quality infrastructure, i.e., the combination of initiatives, institutions, organizations and people that help ensure products and service meet the requirements of customer.

The policy impresses upon the need for national organization to have an international acceptance as well as ensuring enforcement of internationally accepted regime in the country. It further aims to enhance the effectiveness of systems and laboratories of the national accreditation bodies, it shall make necessary provisions to improve the administrative capabilities, HR skills, institution frameworks, information resources and infrastructure.

Policy Statement 50: Accreditation of laboratories in the public and private sectors will be encouraged and facilitated.

Chapter 7

Focusing Emerging and Frontier Technologies

Chapter 7

Focusing Emerging and Frontier Technologies

Emerging technologies are defined by five attributes: radical novelty, fast growth, coherence, prominent impact and uncertainty & ambiguity[35]. These technologies may be currently in development stage, or are expected to be available within the next five to ten years and have the potential to make significant social and economic impacts. Frontier technologies are those emerging technologies that would reshape industry & communications, provide urgently needed solutions to global challenges, and have the potential to displace existing processes[36].

The emerging technologies are now part of national research agendas and are seen as instrumental in meeting global challenges as well as societal needs at national level. These technologies are also seen as strong contributors to future economic growth in an increasingly technology-driven world. The emergence of these new technologies, and their increasing convergence, present both the opportunities and challenges for the policy makers. In the present era, where advancements are happening at a fast pace, research funding is required to be continuously reviewed and updated to take account of the emergence of new scientific fields and to optimize ways to make new discoveries out of them.

Keeping in view the impact emerging and frontier technologies can have on the economic, social, environmental development and welfare of a country, there is a rising need to build capacity in these technologies. With the advent of the fourth industrial revolution, fusion of emerging technologies is blurring the lines between the physical, digital and biological spheres. Emerging technologies are gradually becoming integral parts of production systems and even of our daily life, therefore, evading emerging technologies or ignoring the fourth and even fifth industrial revolution is not an option. It has been put forward by an analyst as “the fourth industrial revolution is like a bullet train coming and it is up to policymakers to prepare and enable the masses to either get on board or risk being a casualty in its path.”[37]

Emerging technologies are being applied in various fields such as agriculture, education, health, environment, manufacturing, textile, water, energy, communication, transport, etc., to solve real-world problems. New applications of these technologies are also being developed on daily basis. One important point to note is that for achieving various development goals in complex contexts, these technologies may not be applied individually but in combination of various

---

[35] Rotolo, D., Hicks, D., & Martin, B. R. (2015). What is an emerging technology? *Research Policy, 44*(10), 1827-1843

[36] https://www.bond.org.uk/news/2019/06/5-frontier-technology-trends-shaping-international-development

[37] Uzair M. Younus, South Asia analyst at Albright Stonebridge Group in Washington D.C.

technologies. Currently, following emerging technologies are taking prominence in the national research agendas:

7.1. Artificial Intelligence

Artificial Intelligence (AI), the largest force in emerging technologies, is a programmed algorithm that automatically processes and applies knowledge expected to transform the future in various aspects. In view of its positive impact on the national economy, the technology is being implemented by the countries across the world in various governance sectors, thus being regarded as an important part of the fourth and fifth industrial revolutions.

7.2. Internet of Things

The Internet of Things (IoT) comprises a system of interconnected computing devices / sensors collecting & transferring data over a network followed by collection & analysis of data resulting into an informed decision making. Such an example is of a temperature sensor that measures the surrounding temperature (data) and continues sending this data to a back-end server. When the ambient temperature surpasses a set threshold (analysis), an alarm gets activated (action). IoT in government provides a real-time data of the city and a centralized system processes that data & helps in governing by effective decision making. Some of the examples are smart grids, smart urban lighting, sewerage & waste management as well as water management.

7.3. 3-D Printing

It is an exciting emerging technology, which is defined as an innovative technology that lets you create a physical object from a digital model in the context of additive manufacturing (adding new material layer) unlike subtractive manufacturing, which remove material's surface layer by layer. This technology can benefit the architectural, automobile and aviation industry sectors to a greater extent and can help them extend their product line.

7.4. Augmented / Virtual Reality

Augmented Reality has massive innovation potential across a wide range of industries and R&D fields. This innovation is currently being applied in domains like healthcare & medical science, art / architecture, transport, infrastructure, tourism, entertainment and education. It enables the strengthening of STEM education, improves citizens' access to healthcare facilities as well as boost the development of robotics, which in turn may open many avenues for excellence in the field of technology for Pakistan.

7.5. Smart Robotics

The paradigm shift of bio-mechatronics and robotics can be observed in two main directions as two extremities; uplifting the performance and miniaturization of the hardware platform while enhancing the intelligence of the integrated system. Smart robotics increasingly finds its application in the hi-tech production sector.

7.6. Blockchain

Blockchain is a decentralized open source shared ledger database using state-of-the-art technology, generally supporting peer-to-peer transactions using cryptography to secure the data from external manipulation. It is capable of revolutionizing the energy trade and making energy resources into digital assets that can be traded on a blockchain. This could open new investing and trading opportunities for the users enabling ease of entry for the novices while fostering innovations leading to community driven change. Furthermore, it has the potential to revolutionize the activities of government vis-à-vis healthcare and electronic health records, digital identities (NADRA), income tax & internal revenue monitoring, voting, secure banking services, supply chain, energy, land transfers, direct benefit transfer, welfare payments and micro grids.

7.7. Intelligent Vehicle

Motor vehicles that have autonomous functions and capabilities such as gathering surrounding data, processing that data into information, and making real-time decisions, are known as intelligent vehicles. These vehicles employ high performance technologies such as on-board sensors for internal & external condition monitoring, navigation systems for positioning, and wireless communication systems for distant communications. These technologies are active research lines and together they enhance the safety, efficiency and environmental performance of the vehicle.

7.8. Biotechnology

In terms of secondary technological advancements, biotechnology is increasingly discussed within ‘synthetic biology’ and converging science. Major changes in our capacity to synthesize viruses and bacterial genomes, with a view to routinely synthesize ‘designer’ genomes are predicted by specialized scientists and entrepreneurs forecasting the evolution of genomics. Talking of the policy agendas, industrial scale biologically-based innovations have begun to be discussed within the goal of establishing ‘bio economies’ such as the use of advanced knowledge of application of genes & complex cell processes to develop new products and use of renewable biomass & efficient bioprocesses to support sustainable production. The desired consequence is for biotechnologies to contribute a significant share of economic output through the invention, development, production, and use of biological products and processes.

7.9. Nanotechnology

It is said to bring about itself a convergence of domains since all things are composed of atomic and molecular substance. Nanotechnology enables molecular restructuring at a nano-level; range 1–100 nanometers, with one nanometer being 10^{-9} meter. It enables needle-free modes of drug delivery, Bionic eye (functional, artificial eye) for imaging, early cancer diagnosis and reduced side-effects from cancer treatment though improved, less invasive medical treatments and therapies. On the other hand, this technology may pose a few challenges due to its increasing utility in warfare and privacy invasion, or it may impinge on the relationship between human beings and technology.

7.10. Materials

It is an interdisciplinary field that deals with the manufacturing and characterization of material for various domains of technology and engineering. It is further classified into aerogel, amorphous metal, conductive polymers, high-temperature superconductivity, fundamentals of surface engineering, surface coating & modification, meta-materials etc.

7.11. Big Data / Data Mining

The process of obtaining convenient & valuable information and knowledge from a set of unprocessed data is known as data mining. It refers to everything that involves bringing computing resources as services rather than products of the internet. Cloud Computing model consists of five essential characteristics, viz., on-demand self-service, ubiquitous network access, metered use, elasticity and resource pooling, as well as three service models (infrastructure as a service, platform as a service and software as a service) or four service models (public cloud, private cloud, community cloud and hybridization).

7.12. Green Technologies

Sustainable development has become a priority agenda in policy forums globally. It has become concern as well as responsibility of all - policy makers, regulators, scientists and industries, to find solutions that may contribute to the creation of sustainable, green and energy efficient industries reducing the ever expanding issue of climate change and the greenhouse gas effect. Development of green sources of energy generation, storage, transmission and distribution as well as promotion of the use of clean technologies in production systems, responsible tourism by provision of green and reliable energy sources at tourism spots / places, innovation in green and energy-efficient daily use electric appliances, and sustainable environmental conservation & management is critical for sustainable future of our planet.

7.13. Space Technologies

Space technologies include spacecraft, satellites, space stations and a wide variety of other technologies including support infrastructure equipment and procedures. Applications of space technologies are not limited to space exploration or national security but they can also be utilized for various other purposes including satellite communications (VSAT business communication systems, mobile telephones & data, satellite radio, wideband data services, etc.) and remote sensing (mapping, agriculture, resource management, land use, etc.). A growing set of industries, which provide positioning, navigation, and timing services based on the Global Positioning System (GPS) also utilize space technologies.

7.14. Information Communication Technologies

Promoting the use of ICT (Information & Communication Technologies) can help usher in sustainable growth of Pakistan's economy. ICT is capable of transforming businesses and creating new products and markets and improving productivity and efficiency in other sectors such as finance, retail, courier, media and textiles. Similarly, the significance of ICTs in strategic sectors like defense, atomic energy, space technology is paramount.

7.15. Quantum Computing

Quantum computing harnesses the peculiar properties of quantum states taking place at a sub-atomic level such as superposition, interference, and entanglement, to perform complex calculations. Though current quantum computers are too small to outperform usual (classical) computers for practical applications, they are believed to be capable of solving certain computational problems, such as integer factorization substantially faster than classical computers. Quantum computing will eventually make computers millions of times faster and more powerful. These computers will have the potential to supercharge Artificial Intelligence, create highly complex data models in seconds, and speed up the discovery of new materials.

Policy Statement 51: Target-oriented programmes will be launched to boost the development and deployment of frontier technologies that impact society and economy across the sectors. An appropriate portion of the National R&D Fund will be reserved to fund R&D projects aimed at product development and commercialization in emerging technologies.

Chapter 8

Revitalizing Science Diplomacy

Chapter 8

Revitalizing Science Diplomacy

Science diplomacy refers to the use of collaborations amongst countries and regions in the field of science, technology and innovation to address common issues and to build sound international partnerships. Interest in the role of science diplomacy in foreign policy & strategy, use & benefit from science diplomacy and leveraging the S&T capacity, in engagement with other countries, regional / multilateral organizations & global agencies have increased in the recent past.

Science diplomacy is not new as since long individuals and governments have utilized science in furthering relationships, although these actions have often not been identified as science diplomacy. In the context of globalization, the need for international cooperation and engagements is more than ever, resultantly the science diplomacy has become important for international diplomacy for a variety of reasons such as science speaks a universal language, it is neutral (does not favour any particular country or community), it is rational, logical and transparent. These and some other features of science make it ideal for diplomacy. The three common aspects and elements of science diplomacy are as given below:

Science in Diplomacy: Where scientific knowledge and evidence is used to inform, support and achieve foreign policy objectives.

Diplomacy for Science: Where diplomatic efforts and resources are aimed at facilitating international scientific and technical cooperation.

Science for Diplomacy: Where scientific cooperation is used as a source of soft power to strengthen or foster foreign relations.

In recent years the technologically advanced countries like the US, Japan and the UK have shown significant interest in science diplomacy. The US, for example created the post of Science and Technology Adviser to the US Secretary of State for strengthening international scientific cooperation and also to watch scientific developments impacting US interests.

Lately, Ministry of Foreign Affairs (MoFA)[38] in its policy has given enhanced weightage to science diplomacy as a tool to create synergies for international scientific and technological cooperation.

8.1. International Collaboration for Socio-Economic Development

Science, Technology and Innovation has been recognized as an engine of the social and economic progress. Science diplomacy can be a useful instrument to

[38] https://mofa.gov.pk/science-for-sustainable-development/

reinforce & make better relations amongst nations by addressing common international issues and exchange of scientific & technological resources. Diplomacy may help lay the foundation for a bi- or multi-national science projects aimed at improving socio-economic condition of the people, where scientists from different nations offer solutions to complex global challenges such as food security, poverty alleviation, climate change, energy utilization, nuclear disarmament, and more recently a pandemic. Working jointly on these global societal issues also bring nations closer to each other.

Cooperation with other countries in the area of science and technology not only raise a country's level of scientific research but also it abilities and competence to play a practical role in the socio-economic development. The benefits of scientific collaboration with technologically advanced countries may vary from scientific collaboration with developing countries; however, both types of collaborations have their own advantages.

Ever since the world has become a global village, several common challenges of global sustainability have been identified and these include environmental degradation threats, food security problems, water security issues, etc. The foreign policy of any country cannot and will not remain apathetic to these challenges. STI has a key role in addressing these challenges and the scientific community need to update the policy makers on the dynamics of the Earth's natural and socio-economic systems.

Policy Statement 52:	Presence and engagement of Pakistani scientists at international fora will be enhanced to safeguard our national interests and increase our international lobbying potential.
Policy Statement 53:	Pakistan's Foreign Missions abroad will be actively used for promotion and marketing of locally produced high-technology products and services.

8.2. International Collaboration for Scientific and Technological Development

Diplomacy for science aims to pave the way for international cooperation both in priority research projects and collaboration between individual researchers.

Over the last couple of decades, international scientific collaboration has become a necessity. There are growing trends where global composition of research staff in innovation and research is considered obligatory.

International collaboration in science and technology not only improve constructive relationships amongst countries but also helps in advancement of science and technology resulting in progression of society and transferring of benefits to the society at large. Initiatives under science diplomacy may range from provision of views / comments on global issues such as environmental issues, food security, climate change, etc. to carrying out exchanges and international collaborative projects as a way to establish positive and cordial relations between countries.

Policy Statement 54:	The government will use diplomacy for better cooperation in the field of science and technology globally, particularly role of S&T based intergovernmental organizations in Pakistan (COMSTEC, COMSATS, ECO-SF, etc.) will be enhanced.
Policy Statement 55:	Efforts will be made to enhance international collaboration in emerging technologies.

8.3. International Collaboration for Diplomatic Gains

Scientific cooperation can begin with the explicit intention of improving relations with other nations. This concept of science diplomacy emerged when the United States used science as a basis for building better relationships with China and the former Soviet Union. Not surprisingly for a reasonably long time the science diplomacy was considered as something of interest of advanced nations with their well-established international roles, and as the leaders in the production of new knowledge and technology. However, with the time, there has been a growing realization among the developing countries that science can support diplomatic efforts, as scientists can provide useful insights and evidence to support their standpoints and safeguard their interests in international treaties on oceans, intellectual property rights, climate change etc.

The role of science and technology in ‘hard power’ capabilities such as military technologies is very obvious and well established. Science for diplomacy uses soft power of science by a country, building upon common values and mutual benefits of partner countries to influence and convince them. This soft power can be differentiated from the conventional ‘hard power’, which uses military might and economic means to coerce the actions and behaviour of other countries. The soft power of science interacts with almost all levels of international relations including cultural diplomacy, public diplomacy, traditional diplomacy, etc. According to former US Secretary of State, Hillary Clinton, “science diplomacy and science and technology cooperation between the United States and other countries is one of our most effective ways of influencing and assisting other nations and creating real bridges between the United States and counterparts.”

International collaboration for diplomatic gains has many forms. Historically political rivals like the US, the USSR and China in the 1970s and 1980s have used science cooperation agreements to symbolize improving political relations. Science for diplomacy can also be reflected in the creation of new institutions. An example in this regard would be establishment of European Organization for Nuclear Research (CERN) after World War II facilitating post war contacts between scientists from war time rival countries. Educational scholarships also help build networks and encourage partnerships. Recently, there is also a growing interest among developing nations to embrace science diplomacy, with the realization that science can support diplomatic efforts, as scientists can provide insights and evidence to support new international treaties on oceans, intellectual property rights, climate change etc.

Policy Statement 56: The Government will make efforts to acquire and prudently utilize scientific advice in the achievement of foreign policy objectives and facilitate local STI stakeholders to collaborate with international counterparts.

8.4. Capacity Building for Science Diplomacy

Scientists and diplomats are two distinct communities and science diplomacy focus to strengthen the interest and motivations of both the communities. The scientists must have the capacity to give advice and at the same time diplomats need to be in a position to receive and implement that advice.

Effective science diplomacy requires diplomats and international/foreign policy makers to have some level of science literacy. It also requires that scientists convey their work in an understandable and intelligent way keeping in view the wider policy context.

To provide enhanced and effective science & technology advice in multilateral agreements and its implementation, it is important to carry out capacity building of both scientists and diplomats. However, the capacity building of scientists is in understanding the realities of foreign policy making whereas the diplomats need to be informed about the role and limits of science in foreign policy.

Policy Statement 57: Capacity of relevant government officials (diplomats and scientists) will be enhanced for effective science diplomacy.

8.5. Factors Hindering International Collaboration

International Collaboration in science and technology is very much dependent on a number of parameters such as funding, time, bureaucratic procedures, compatibility between collaborators and even physical distance. Lacking and deficiencies in one or more of these parameters can seriously hamper international collaboration in science and technology.

Inadequate funding will weaken a national science system and will result in a decline of the International S&T cooperation. Studies across many countries and regions have shown that lack of funding is one of the most common barriers to international S&T cooperation. Lack of funding affects conducting research but also travel by researchers, convening of thematic workshops etc. Another important challenge is the Intellectual Property (IP) issues and other legal issues in international collaboration. Potential IP issues resulting from collaboration and the related legal relationship between various partners need to sort-out in the formulation stage to avoid conflicts and differences later on.

To overcome these challenges adequate measures from the government in terms of increasing funding opportunities, flexible government policies, creating projects for mutual benefits etc. could be very handy.

Policy Statement 58:	Barriers to the international mobility of scientists will be removed and support mechanisms will be strengthened.
Policy Statement 59:	Practical outcomes of the agreements and MoUs with other countries in the field of science and technology will be enhanced.

Chapter 9

Ensuring Policy Implementation

Chapter 9

Ensuring Policy Implementation

9.1. Policy Implementation Coordination and Monitoring

9.1.1. Steering Committee for Policy-Implementation Coordination and Monitoring

A Steering Committee, under the chairmanship of the Federal Minister for Science and Technology, and with representation from different stakeholders in the federal as well as provincial governments will be constituted. The Steering Committee will coordinate implementation of the policy across different federal ministries and provincial departments. The Committee will also monitor the implementation process of the policy through periodic review of the progress of the implementation, and make amendments and modifications in the implementation process, if and as required. The Steering Committee will be assisted by two bodies, i.e., Policy Implementation Advisory Board and Policy Implementation Coordination Unit.

9.1.2. Policy Implementation and Monitoring Advisory Board

A Policy Implementation Advisory Board will be constituted. The composition of Advisory Board shall be drawn from government functionaries, academia and industry including prominent entrepreneurs. Members of the Advisory Board shall be selected for three (3) years. The Advisory Board will serve as an expert advisory body to the Steering Committee, *inter alia*, on the following:

i. In crafting the national research agenda based on historically contingent and regionally relevant research areas complimenting the national priorities in line with the STI Policy 2022.

ii. In devising and periodically revising the implementation strategies for National STI Policy 2022.

iii. In crafting plans and programmes including those for human resource development in realizing the objectives set forth in STI policy.

iv. In identifying actors, ascertaining their role(s), identifying systemic impediments, if any, and recommending measures to mitigate consequences of such impediments that have bearing on implementing the policy.

v. In instituting an independent annual assessment of the STI policy.

9.1.3. Policy Implementation Coordination and Monitoring Unit

A Policy Implementation Coordination and Monitoring Unit, adequately staffed with personnel having relevant experience, skills and aptitude, will be established in the Ministry of Science and Technology. The exclusive function of this Unit will be to pursue implementation of the policy across various federal ministries and provincial departments working in different sectors. The Unit will be headed by an Additional Secretary level officer and will report directly to Federal Secretary to the Government of Pakistan, Ministry of Science & Technology and to the Federal Minister, Science & Technology. The Implementation Coordination and Monitoring Unit would be responsible, but not limited, for the following:

i. Conceiving, preparing, coordinating, collating and synthesizing plans and programmes in line with the National STI Policy - 2022, either directly or through assistance provided by all relevant organizations, entities and individuals.

ii. Processing the plans and programmes for approval and allocation of funds by the competent quarters.

iii. Instituting mechanisms for implementation of plans and programmes and keeping a vigil on their progress, their timely implementation and taking measures to arrest gaps in implementation, if so warranted.

iv. Identifying issues and bottlenecks in implementation, and suggest corrective measures to the Steering Committee for taking appropriate decisions and actions. The Steering Committee may refer the matters to the Prime Minister, or other appropriate levels if not resolved at the level of the Steering Committee.

v. Collating and analyzing data and information and preparing recommendations for consideration of the Steering Committee.

9.2. Preparation of Implementation Plan

Detailed Implementation Plans will be prepared by all the relevant federal ministries and provincial government departments and agencies as early as possible after approval of the National Science, Technology and Innovation Policy. Implementation plan will include information about implementing agency, estimated cost, time duration, major stakeholders, milestones, deliverables, and key outcomes, about each initiative to be taken under the National STI Policy - 2022. The Policy Implementation Coordination Unit will coordinate preparation of the implementation plans by relevant agencies and based on these compile the National Implementation Plan of the policy.

Policy Statement 60:	Appropriate policy implementation, coordination and monitoring mechanisms will be established to ensure policy implementation across various federal ministries and provincial departments.
Policy Statement 61:	A detailed implementation plan for the National Science, Technology and Innovation Policy - 2022 will be prepared.

Consolidated List of Policy Statements

Consolidated List of Policy Statements

Policy Statement 1: Through wider consultations, specific challenges under the key societal development challenges will be defined, and science, technology and innovation efforts will be directed to address these challenges on a regular and consistent basis.

Policy Statement 2: National R&D infrastructure will be strengthened, through ensuring availability and proper utilization of latest equipment, to enhance its capacity to contribute in societal development.

Policy Statement 3: Measures will be taken to increase the number of researchers per million population to bring it at par with the regional leaders.

Policy Statement 4: Annual national R&D spending, as percent of GDP, will be enhanced up to the world average through various measures such as institution of a National R&D Fund, increasing share of industry in the total national R&D spending, etc.

Policy Statement 5: Cross learnings across provinces will be encouraged to address developmental challenges and help in realizing Sustainable Development Goals.

Policy Statement 6: S&T research culture will be reoriented, wherein, the performance of researchers will be assessed, recognized and rewarded on the basis of both academic achievements as well as socio-economic impact.

Policy Statement 7: Access to internet will be enhanced across the country covering the aspects of availability, affordability, relevance and readiness.

Policy Statement 8: An interface between media persons, scientists and science communicators will be developed for enhancing understanding of different stakeholders regarding the role of science, technology and innovation in the societal development, and uplifting status of scientists in the society.

Policy Statement 9: Cyber security will be improved by building capacity, and by developing robust indigenous systems, wherein, data physically resides inside country’s territorial boundaries and is protected by indigenous security mechanisms.

Policy Statement 10: Ten cities will be transformed into “smart cities” in a phase-wise manner within the next ten years, by adopting the latest concepts of smart urban planning, technology integration, and service provision.

Policy Statement 11: Institutions and mechanisms for scientific advice to the government at the highest level will be strengthened at the Federal as well as the Provincial level.

Policy Statement 12: Appointment of “right STI leaders” in the S&T organizations will be ensured through putting in place appropriate mechanisms for determination and assessment of qualifications, knowledge, experience, skills, and aptitude in accordance with the specific mandate of the concerned organization.

Policy Statement 13: For ensuring evidence-based decision-making, relevant organizations will be strengthened to enhance their capabilities and expertise in data collection, storage and analysis in their respective domains.

Policy Statement 14: National Science, Technology and Innovation Management Information System (STI-MIS), including a centralized data repository, will be established as a knowledge hub to support evidence-based decision-making in science, technology and innovation.

Policy Statement 15: Programmes will be initiated to encourage STI policy research in the public policy institutes, S&T organizations, universities and industrial establishments to boost policy research on the issues concerning STI policy in the country, and build a network of STI policy researchers in Pakistan to strengthen knowledge base for evidence-based STI policy formulation.

Policy Statement 16: Science and technology (S&T) organizations will be provided uniform service and salary structures as well as career development structures, eventually creating a single S&T cadre.

Policy Statement 17: National Commission for Science and Technology will be revived to provide leadership and guidance in the development of a strong and well-integrated STI ecosystem directed towards welfare of the people, socio-economic development and security of Pakistan.

Policy Statement 18: Science, technology and innovation will be included in the Constitution of Pakistan through a constitutional amendment, and a Science, Technology and Innovation Act will be promulgated to provide legal cover to such activities in the country.

Policy Statement 19: A holistic approach to human resource development will be adopted to develop a continuous pool of knowledge workers for the national STI ecosystem.

Policy Statement 20: Qualified and skilled human resource in the identified emerging technologies will be produced as per requirements.

Policy Statement 21:	Cognitive skills of the children will be developed, by enhancing teaching skills of science teachers, modernizing syllabi and adopting novel teaching methods such as storytelling of scientific concepts, learning through playing, field trips, etc.
Policy Statement 22:	The concept of STEM education will be implemented in letter and spirit in the selected schools to be replicated at a larger scale.
Policy Statement 23:	Efforts will be made and mechanism would be developed to ensure the participation of Pakistan in the global education testing systems.
Policy Statement 24:	Science education at the university level will be revamped to inspire science graduates to align their research with real-world social problems and development of their indigenous solutions.
Policy Statement 25:	Steps will be taken to produce “industry-ready” human resource equipped with entrepreneurial skills for industry and other economic sectors.
Policy Statement 26:	New generation of scientists and researchers will be supported and promoted as the key drivers of socio-economic development by raising the attractiveness and prestige of scientific careers compared to non-scientific careers.
Policy Statement 27:	Women participation in science and technology will be enhanced at all levels of education and research.
Policy Statement 28:	Science and technology oriented social culture, harmonized with our religious and traditional cultural values, will be promoted.
Policy Statement 29:	The National Academy of STI Management and Planning will be established for provision of in-service trainings to scientific community and science & technology orientation to other stakeholders of STI such as parliamentarians, bureaucrats, industrialists, media personnel, civil society representatives, etc.
Policy Statement 30:	Future need assessment of STI human resource will be carried out focusing on the demand side of the S&T human resource mainly for catering the key societal development challenges.
Policy Statement 31:	Funding will be enhanced for all stages of product development, i.e., research, patent filing, prototype development & technology transfer and commercialization.
Policy Statement 32:	National and institutional Intellectual Property policies will be formulated, and awareness of all stakeholders will be enhanced regarding importance of intellectual property rights, including geographical indicators of unique raw material & crops, etc.

Policy Statement 33: Measures will be adopted to enhance quintuple helix linkages for full spectrum engagement of all elements of quintuple helix (i.e. academia, industry, government, society and environment), and in this regard appropriate forums will be established / strengthened.

Policy Statement 34: Annual Science and Technology Expos will be organized on regular basis to encourage indigenous technology development and commercialization.

Policy Statement 35: Provisions will be created for industry to apply for research funding as primary applicants contingent upon involving academia and/or R&D organizations in research and intellectual property co-ownership.

Policy Statement 36: Incentives, such as permission of consultancy, profit sharing, more freedom to interact and win projects, etc., will be provided to the researchers in the industry related projects.

Policy Statement 37: Establishment of multidisciplinary research groups, through pooling resources and expertise, will be encouraged and facilitated, to work on real-world socio-economic problems and their indigenous solutions as well as targeted product development.

Policy Statement 38: A national framework of integrated civil-military R&D cooperation will be established including a National Civil-Military R&D Cooperation Board.

Policy Statement 39: Social interaction of educated youth with entrepreneurial role models will be increased to change their perceptions of risk while creating startups.

Policy Statement 40: Entrepreneurship will be taught, starting from graduation level, to students of all “science and technology degrees”, especially engineering and technology students, while training and facilitation will be made available for the budding freelancers in technology-based businesses.

Policy Statement 41: Academicians’ understanding of business world will be enhanced through trainings, academia-industry immersion programmes and market intelligence exercises.

Policy Statement 42: Network of National Incubation Centres (NICs) / Business Incubation Centres (BICs), in all sectors of economy, will be expanded and strengthened in both the public and private sectors.

Policy Statement 43:	Support will be provided to startups in priority emerging technologies meeting key societal development challenges, especially those which would be involved in R&D and commercialization of the products in collaboration with universities and government R&D organizations.
Policy Statement 44:	Funding support will be provided through establishment of venture capital funds, creation of angel networks, outreach to the Pakistani expatriate community, etc.
Policy Statement 45:	Tax exemptions, loans and insurance facilities will be made available for the startups.
Policy Statement 46:	Growth of technology based SME clusters will be supported with incentives for modernization and tech enablement.
Policy Statement 47:	Development of Special Technology Zones (STZs) will be promoted and facilitated across the country, especially in SEZs under CPEC and under-developed areas.
Policy Statement 48:	Five universities will be selected, initially, to establish technology parks in their close proximity; each targeting a specific sector of economy, e.g., IT, agriculture, energy, textile etc., (attracting national and international industry in the Park) to enhance product development in those areas.
Policy Statement 49:	Quality and Standards infrastructure will be strengthened to improve quality of products leading to import substitution on the one hand and export enhancement on the other hand.
Policy Statement 50:	Accreditation of laboratories in the public and private sectors will be encouraged and facilitated.
Policy Statement 51:	Target-oriented programmes will be launched to boost the development and deployment of frontier technologies that impact society and economy across the sectors. An appropriate portion of the National R&D Fund will be reserved to fund R&D projects aimed at product development and commercialization in emerging technologies.
Policy Statement 52:	Presence and engagement of Pakistani scientists at international fora will be enhanced to safeguard our national interests and increase our international lobbying potential.
Policy Statement 53:	Pakistan's Foreign Missions abroad will be actively used for promotion and marketing of locally produced high-technology products and services.

Policy Statement 54:	The government will use diplomacy for better cooperation in the field of science and technology globally, particularly role of S&T based intergovernmental organizations in Pakistan (COMSTECH, COMSATS, ECO-SF, etc.) will be enhanced.
Policy Statement 55:	Efforts will be made to enhance international collaboration in emerging technologies.
Policy Statement 56:	The Government will make efforts to acquire and prudently utilize scientific advice in the achievement of foreign policy objectives and facilitate local STI stakeholders to collaborate with international counterparts.
Policy Statement 57:	Capacity of relevant government officials (diplomats and scientists) will be enhanced for effective science diplomacy.
Policy Statement 58:	Barriers to the international mobility of scientists will be removed and support mechanisms will be strengthened.
Policy Statement 59:	Practical outcomes of the agreements and MoUs with other countries in the field of science and technology will be enhanced.
Policy Statement 60:	Appropriate policy implementation, coordination and monitoring mechanisms will be established to ensure policy implementation across various federal ministries and provincial departments.
Policy Statement 61:	A detailed implementation plan for the National Science, Technology and Innovation Policy - 2022 will be prepared.

Coordination Committee & Working Group

Coordination Committee & Working Group

Coordination Committee

Dr. S. Zaheer Hussain Shah
Joint Scientific Advisor (P&C)
Ministry of Science and Technology, Islamabad

Dr. Tariq Bashir
Senior Research Officer (Sci.)
Pakistan Council for Science and Technology, Islamabad

Engr. Farid Bakhtiar
Senior Research Officer (Tech.)
Pakistan Council for Science and Technology, Islamabad

Working Group

Prof. Dr. M. Aslam Baig
Secretary General, Pakistan Academy of Sciences, Islamabad

Dr. Abid Qaiyum Suleri
Executive Director, Sustainable Development. Policy Institute, Islamabad

Dr. Syed Hussain Abidi
Member (Science and Technology), Ministry of Planning Development & Special Initiatives, Islamabad

Dr. Arabella Bhutto
Professor, Mehran University of Engineering and Technology, Jamshoro

Dr. Syed Adnan Qasim
Registrar, National University of Technology (NUTECH), Islamabad

Engr. Dr. Nasir Mahmood Khan
Additional Registrar, Pakistan Engineering Council, Islamabad

Dr. Zain-ul-Abdin
Director General (R&D), Higher Education Commission, Islamabad

Dr. Muhammad Ali Muhammad
Director (Research), National University of Sciences and Technology, Islamabad

Mr. Asim Ayaz
General Manager (Policy), Engineering Development Board, Islamabad

Dr. Khalid Khan
Director, Department of Science & Technology, Khyber Pakhtunkhwa

Dr. Mirza Habib Ali
Director Research Support, Pakistan Science Foundation, Islamabad

Dr. Ahsan Feroze
Director, International Linkages, Pakistan Science Foundation, Islamabad

Dr. Afzal Hussain Kamboh
Director, Pakistan Council of Renewable Energy Technologies, Islamabad

Dr. Tahir Naeem
Director/Head (P, D and HRD), Directorate of Planning, Development & Human Resource Development, COMSATS University, Islamabad

Dr. Tariq Bashir
Senior Research Officer (Sci.), Pakistan Council of Science & Technology, Islamabad

Engr. Farid Bakhtiar
Senior Research Officer (Tech.), Pakistan Council of Science & Technology, Islamabad

Dr. Syed Zaheer Hussain
Joint Scientific Adviser (P&C), Ministry of Science and Technology, Islamabad

Acknowledgment

Acknowledgment

Feedback on the draft National STI Policy - 2022 document received from the following ministries, departments, organizations and individuals is hereby acknowledged with thanks:

1. ACDIS-II & Science Diplomacy Division, Ministry of Foreign Affairs, Islamabad
2. Board of Investment, Prime Minister's Office, Islamabad
3. COMSATS University Islamabad, Ministry of Science and Technology, Islamabad
4. DP R&D Coord. Joint Staff Headquarters, Rawalpindi
5. Drug Regulatory Authority of Pakistan, Ministry of National Health Services Regulations and Coordination, Islamabad
6. Engineering Development Board, Ministry of Industries and Production, Islamabad
7. Higher Education Commission, Islamabad
8. Information, Science & Technology Department, Government of Sindh, Karachi
9. Intellectual Property Organization of Pakistan, Ministry of Commerce, Islamabad
10. Inter-Services Intelligence Secretariat, Ministry of Defence, Islamabad
11. Karachi Tools Dies & Moulds Centre, Ministry of Industries and Production, Karachi
12. Ministry of Communications, Islamabad
13. Ministry of Finance and Revenue, Finance Division, Islamabad
14. Ministry of Housing and Works, Islamabad
15. Ministry of Planning, Development & Special Initiatives, Islamabad
16. Ministry of Railways, Islamabad
17. National Energy Efficiency & Conservation Authority, Ministry of Energy, Power Division, Islamabad
18. National Engineering Services Pakistan (Pvt.) Ltd., Ministry of Energy, Power Division, Islamabad
19. National Institute of Electronics, Ministry of Science and Technology, Islamabad
20. National Institute of Oceanography, Ministry of Science and Technology, Karachi
21. National Transmission & Despatch Company Ltd., Ministry of Energy, Power Division, Islamabad

22. National University of Sciences and Technology (NUST), Ministry of Science and Technology, Islamabad
23. Naval Research and Development, Naval Headquarters, Ministry of Defence, Islamabad
24. Operations and Plans Branch, Joint Staff Headquarters, Rawalpindi
25. Organization of Islamic Cooperation Standing Committee on Scientific & Technological Cooperation, Islamabad
26. Pakistan Academy of Engineering, Karachi
27. Pakistan Armed Services Board Secretariat, Ministry of Defence, Rawalpindi
28. Pakistan Council of Research in Water Resources, Ministry of Science and Technology, Islamabad
29. Pakistan Industrial Technical Assistance Centre, Ministry of Industries and Production, Lahore
30. Pakistan Institute of Development Economics, Ministry of Planning, Development & Special Initiatives, Islamabad
31. Pakistan Maritime Security Agency Headquarters, Ministry of Defence, Karachi
32. Pakistan Scientific and Technological Information Centre, Ministry of Science and Technology, Islamabad
33. Planning and Development Department (Science & Technology Section), Government of Sindh, Karachi
34. Private Power and Infrastructure Board, Ministry of Energy, Power Division, Islamabad
35. Services & General Administration Department, Government of Sindh, Karachi
36. Small and Medium Enterprises Development Authority, Ministry of Industries and Production, Lahore
37. Special Technology Zones Authority, Prime Minister's Office, Islamabad
38. STEDEC Technology Commercialization Corporation, Ministry of Science and Technology, Lahore
39. Strategic Plans Division, Rawalpindi
40. Strategic Policy Planning Cell, National Security Division, Prime Minister's Office, Islamabad
41. Survey of Pakistan, Ministry of Defence, Rawalpindi
42. Technology Upgradation & Skill Development Company, Ministry of Industries and Production, Lahore
43. Dr. Ahmed Zubair, Chief Economist, Planning Division, Islamabad
44. Dr. Ammar Younas (PhD Scholar), University of Chinese Academy of Sciences, China

45. Dr. Atta-ur-Rahman, FRS, Chairman, PM Taskforce on Science & Technology, Islamabad
46. Dr. Hafiz A. Pasha (formal Federal Minister), Professor Emeritus, Beaconhouse National University, Lahore
47. Dr. Haris Aziz, Scientia Associate Professor, University of New South Wales, Sydney, Australia
48. Dr. Haroon Ahmed, Professor Emeritus of Microelectronics, University of Cambridge, UK
49. Dr. Minhaj A. Qidwai, Founder, Centre for Health Innovation and Transformation, Karachi
50. Dr. Muhammad Ashraf, Ex-Chairman, Pakistan Science Foundation, Islamabad
51. Dr. Muhammad Sabih Anwar, Professor of Physics, Ahmad Dawood Chair & Dean, Syed Babar Ali School of Science and Engineering, Lahore University of Management Sciences, Lahore
52. Dr. Muhammad Usman Awan, Professor / Director, Institute of Quality & Technology Management / Dr. Muhammad Khurram Shehzad, Associate Professor, Department of Data Science, University of the Punjab, Lahore
53. Dr. Pervez Tahir, Ex Chief Economist, Ministry of Planning, Development & Special Initiatives, Islamabad
54. Dr. Rizwan Riaz (AVM Rtd.),S.I., Pro-Rector (RIC), National University of Sciences & Technology, Islamabad
55. Dr. S.T.K Naeem, Ex-Chairperson, Pakistan Council for Science & Technology, Islamabad
56. Dr. Tasawar Hayat, Secretary General, Pakistan Academy of Sciences, Islamabad
57. Engr. Fazal Ahmed Khalid, Chairman, Punjab Higher Education Commission, Lahore
58. Engr. Rukhsana Rahooja Ex-Chairperson, Council for Works and Housing Research, Karachi
59. Mr. Asad Faizi, Founder of multiple startups, Founder & CEO, CloudPlex.io
60. Mr. Khushal Khan, Country Manager, Citizen Corps, Swat

Government of Pakistan
Ministry of Science and Technology
https://www.most.gov.pk
Pakistan Council for Science and Technology
https://www.pcst.org.pk
Islamabad

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