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Policy Innovation For Societal Change: Examining STI Policy In Pakistan

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Abstract:

This study is a case study where the principle of the exploration of all aspects of Science, Technology and Innovation (STI) policies of Turkey and Iran is put into action by the author who aims at illuminating simultaneously the areas that are in the need of improvement within the Pakistan's STI (Science, Technology and Innovation) framework. The research is intended to be a critical study on the STI policies of these states and builds the literature that not only explains the elements of STI policies that works but also learn the parts of the policy that does not. The study will be held employing Omar's six principles alongside a 22-indicator evaluation matrix for assessing and proving the effectiveness of the existing STI initiatives at the country-level. In addition to this, the study will highlight the issue areas that must be improved in order to accomplish the set policy targets. Our research process allows for cross-country analysis of STI policies that take into account your research purpose. The necessary analysis of the historical evolution, the implementation of the policy and its result for the intelligent products, the economic growth and the level of human capital development are included. In that stream, there is one st[1]riking, the NASTIC (Need Assessment of Science, technology, and Innovation Cycle) framework. This framework is being developed to be distinctive from what it used to be before in order to face and conquer the problems Pakistani STI policies have faced in the past. Also, it is meant to be applied while observing the structure for any improvements or changes that may need to be made. On one hand, these conclusions can provide the stakeholders, decision-makers and researchers of Pakistan's Ministry of Science and Technology (MoST) with an evidence-based validation. The present study endeavors in subliming the areas that science, technology and innovation (STI) policy measures in Pakistan need to be must more developed by introducing its policy plan for such improvement. This study is thus contributing to the studies that are based on STI policy evaluation, reinforce their conception by focusing on the comparative analysis and policy adjustments as the key factors of success.

Keywords: *STI policy, Turkey, Iran, Pakistan, Omar framework, policy responses, NASTIC framework, sustainable development.*

Introduction:

To encourage research, development, and technical improvement in the nation, Pakistan has enacted three science, technology, and innovation policies over the years. However, the lack of

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proper implementation hindered Pakistan from fully realizing its potential in the STI sector. While the policies laid out ambitious visions and objectives, they failed to achieve the desired results due to the absence of concrete action plans. The Pakistan Vision 2025 placed a strong emphasis on innovation, research, and technology but did not develop targeted actions to track progress. As a result, Pakistan has fallen short of improving its technological prowess and supporting innovation-driven industries as envisioned. Similarly, the National STI Policy and National Innovation Policy aimed to strengthen academic-industry linkages and encourage entrepreneurship. However, without dedicated implementation roadmaps, partnerships and an innovation culture have not been effectively fostered.

Initiatives by HEC provided funding and support for research but lacked coordination with industry needs. Consequently, research commercialization could not be enhanced. The IT policy strived to expand access to technology, but clear directives and resource allocation were missing. The space policy sought to boost capabilities but lacked implementation directives. The renewable energy regulations also failed to accelerate adoption due to the absence of an action framework. If concrete action plans outlining short, medium, and long-term targets, timelines, responsibilities, and resource requirements were developed for each policy, Pakistan could have made considerable progress in the STI domain. With dedicated roadmaps and coordination among stakeholders, the country would have been able to strengthen innovative ecosystems, boost research impact, grow technology industries, and nurture human capital. Proper implementation through well-defined action plans holds the key to transforming policies into reality and helping Pakistan flourish through science, technology, and innovation.

The innovation performance of each nation in 2020 is indicated by these rankings and scores. The rankings show each nation's position in relation to other nations; higher performance is shown by lower numbers. The Innovation Inputs and Outputs scores denote distinct facets of the innovation process. Inputs pertain to elements that foster innovation, while outputs represent the tangible consequences and achievements of innovation endeavors. In conclusion based on above discussion, it is evident that plans of Iran's are centered on enhancing scientific capabilities and achieving technical self-reliance despite being subject to sanctions. In case of Turkey, policies for science, technology, and innovation present chances for collaboration, knowledge exchange, and economic progress. With the help of these measures, Pakistan may strengthen its own ecosystem of science, technology and Innovation, with cooperation of Turkish and Iranian counterparts to promote innovation-driven economic growth.

Pakistan has made significant progress in the fields of STI to some extent, however, there are problems as well as gaps that should be addressed and closed so that STI could be used as a tool of national development. One key issue is a lack of investment into R&D part. Compared to the other countries, the allocated funding for STI operations, such as research grants and infrastructure development is incredibly cheap (Ozkaya et al., 2021). In order to support scientific research, innovation and commercialization of technological products, ample funding is indispensable. The cooperation among academia, industry and government is the essence for converting the theoretical research findings into useful tools and products and for creating new enterprises that are innovative in nature. In Pakistan, the industry is usually lack of communication and coordination among these industries (2016). Establishing and sustaining those bonds and creating highly developed vehicles for the transmission of knowledge and technology would be the key.

Immigration of biologists, doctors, and other talents who are searching for and go to other countries is a major issue for Pakistan. The deficits of acceptable career opportunities, incompetent research infrastructure and lack of attracting entrepreneurs and innovators

contribute to it. An innovative STI environment is possible only when talented individuals are attracted and retained in order to make it a success. To generate industrial demand, commercialize research, and transfer technology, universities and businesses need collaborate. Several times the gap between research and business is witnessed in Pakistan (Malik et al., 2021). The business world and university sector should finance studies related to modern technologies that provide better services to customers.

Scarcity of infrastructure and research centers is the major challenge in the implementation of pioneer science research labs. In Pakistan, under the low capacity laboratories, specialized research institutes, and modern scientific instruments research in STI is hindered. Establishing and improving infrastructures to support cutting-edge investigation is indispensable in advancing science and research. A framework to intellectual property rights that is too lacking in strength may lead to unwillingness of transferring technologies and innovation. In order to effectively keep innovators and encourage the utilization of intellectual property, Pakistan should improve its legislation, enforcement mechanisms and public cognition about the IPR.

Research Objectives:

1. To explore gaps in the role of policy making institutes for explored dimensions of improvement for meeting key societal challenges of STI policy in Pakistan.

2. To propose a Need Assessment STI Cycle (NASTIC) framework for explored dimensions of improvement for diagnosing and meeting the key societal challenges in Pakistan.

This article introduces the Science, Technology and Innovation policy and the imperative role it plays in society development and economic up gradation of our country like Pakistan. Summarizing Turkey and Iran, the conceptual idea of formulating the consequences for Pakistan is discussed. In conclusion, the chapter poses a question which the thesis aims to demonstrate later.

Literature Review

According to ODTÜ TEKPOL (2021) the role of government in supporting research and innovation has recently emerged as a focus of the government's growing missions to influence STI policy. Government regulation of technological advancement and innovation is changing from a passive state mode to an active state mode where government creates markets. A few examples from different countries and technological fields are provided in The Entrepreneurial State, a book that investigates how governments might affect technological advancement by actively creating new markets rather than merely regulating those that already exist. It is asserted that enterprises are rarely the source of novel technological advancements and scientific breakthroughs. The market and these technologies are developed by governments up to the point where businesses can take risks.

Alkan, A (2023) Science and Technology Studies (STS) in Turkey is international interaction that aims to democratize techno scientific knowledge-making processes while negotiating the intricacies of institutional structures and bureaucratic constraints. The integration of STS into Turkish institutions has been made possible by scholars who have bridged ideas and methods across national boundaries, despite the obstacles presented by political-bureaucratic organizations. Although individual endeavors have played a crucial role in the establishment of STS in academia, obstacles still stand in the way of the field's complete institutionalization

in Turkey. Due to these difficulties, people are thinking more critically about the generative potential of adversity and are beginning to practice STS "outside" of conventional academic settings. This change emphasizes how crucial it is to establish hybrid knowledge spaces, like STS, IstanbuLab started with the goal of democratizing the processes of producing techno scientific knowledge in Turkey.

Techno scientific innovations with a critical eye, grounded in the realities of the homeland, by creating new forums for STS debate, both in academia and the public domain. These conversations emphasize STS in Turkey as a forum for democratization and dissent, questioning established conventions and promoting inclusive methods of knowledge production. the field's breadth by incorporating works that are now in Turkey, which are not commonly considered contributions to STS, into the STS framework and language. Through this act of translation, STS becomes more visible outside of its traditional limits, encouraging others to embrace an STS viewpoint and interact with other techno science viewpoints in the Turkish environment. By means of these endeavors, STS in Turkey persistently develops as a vibrant and all-encompassing domain, adaptable to regional circumstances and dedicated to democratizing techno scientific methodologies.

The policy recommendations made by Türk, T. G. (2023) are intended to remove the obstacles preventing Turkey's State-Owned Enterprises (SOEs) from advancing technologically. The two primary areas of emphasis for these ideas are funding/budgeting tactics and employment policies. First, when it comes to employment policies, the focus is on encouraging merit-based hiring procedures for R&D in SOEs. The goal of this strategy is to draw in and keep elite people, which will improve these companies' capacity for research and development.

Second, in terms of money and budgeting, the recommendations seek to augment the amount allotted especially for research and development endeavors conducted by SOEs. To further encourage autonomy and creativity inside SOEs by reducing reliance on government money, the proposal also calls for the formation of a separate budget for research and development. The creation of laws and regulations is one of the policy tools used to carry out these recommendations. Turkey's SOEs can improve their technology capabilities and become more inventive, competitive, and productive by implementing these steps. Furthermore, by promoting a technology-driven economy, these projects can aid in Turkey's overall economic growth and development. It's important to understand, though, that these recommendations are not all-inclusive and that, in order to be as effective as possible, they could need more research and development. They ought to be put into practice in conjunction with other beneficial policies and plans that support Turkey's economic expansion.

Moreover, technology development is a complex topic, and the suggested regulations might need to be modified to account for the variety of industries in which SOEs operate. The principal aim is to establish the framework for essential policies that expand the state's and SOEs' perspectives. The results of this investigation will serve as a basis for other studies on the subject.

SARIGÜL (2022) Businesses are under more and more pressure to stay competitive in today's globalized market and keep up with technology improvements. Businesses have created Research and Development (R&D) divisions in order to address this challenge by promoting internal innovation and adjusting to changing market conditions. Diverse approaches to innovation have surfaced as companies aim to increase their market share and adapt to evolving conditions. These tactics include traditional innovation, copycat innovation, defensive innovation, aggressive innovation, dependent innovation, and opportunity monitoring

strategies. Although putting these tactics into practice could be expensive in the near run, the state of the market frequently demands such expenditures. But in the long run, businesses that select the appropriate innovation approach can increase revenue by matching consumer needs and achieving steady expansion.

The aviation sector is known for its dynamic nature, and to increase market share and competitiveness, innovative techniques are essential. Research suggests that adopting innovative tactics enhances worker productivity and helps businesses succeed. Turkish businesses have been noted for their notable shift from closed to open innovation strategies, which reflects the changing nature of the business environment and the demand for flexibility. Innovation techniques have been demonstrated to impact customer happiness, business success, and employee motivation in Turkey's civil aviation industry. To satisfy the changing demands and expectations of their customers, businesses need to continuously develop and adopt creative tactics. Differentiation and an emphasis on innovative service offerings are crucial for success given the competitive nature of the aviation sector. Employers have been able to maximize profits as a consequence of these techniques' application, which has raised staff motivation and enhanced corporate performance, competitive advantage, and customer loyalty cutthroat business environment, implementing effective innovation strategies that are suited to organizational structures and market demands is critical to long-term success. Through embracing innovation and cultivating an adaptable culture, companies can improve performance, manage dynamic environments, and achieve long-term growth.

Turkey is caught in a scenario where it can neither be inactive nor aggressive. Undoubtedly, the government is more engaged in specific areas, like energy and defense, as well as specialized technology, such unmanned aerial vehicles and, more recently, electric vehicles. The establishment of the Indigenous Technology Directorate inside the Ministry of Industry and Technology in 2020 is another step in the direction of a more proactive strategy. This is well shown by the auto sector. After the Customs Union agreement with the European Union (EU) in 1996, the government mostly played a regulatory role, and the car industry was largely left to market forces. As a result of the Turkish Automobile Initiative Group (TOGG), this is currently changing.

The decision to invest and the continued work to develop a fully electric automobile have significantly altered other companies' perspectives. Many businesses are now aggressively pushing fully electric and hybrid vehicles far sooner than anticipated. For instance, Ford is starting up the first battery assembly plant in Turkey. As a reflection of the active state mode, mission-oriented policy is increasingly being applied by both wealthy and poor nations. The US missions, France and Germany adopting mission-oriented concepts, Brazil's contribution to the development of renewable energy technology and the health sector, and Italy's most recent mission-creation initiative are just a few examples from around the world. Missions became even more appealing as it was revealed that the upcoming EU Framework Program, Horizon Europe, would follow mission-oriented policy principles. With a budget of more than €100 billion, Horizon Europe will be the premier research and innovation fund in the EU for the following seven years (2021–2027). New missions differ from prior missions (like the US man on the moon program) in that "sustainability" is a key objective. Planning for research and innovation revolves around a mission-defined, bold objective (such having 100 carbon-free cities in the EU by 2030). It is dubious to imply that Turkey is pursuing a mission-oriented policy. Although the TOGG electric car's claim of a fully electric vehicle on the road by 2022 may sound ambitious, it cannot be said that all research and innovation efforts are directed toward achieving this objective.

As seen by recent attempts, the Turkish government wants to actively participate in technology production. For instance, the Covid-19 platform displays all activities financed by the government, such as study against Covid-19, along with actions planned by the government. The National Space Program is another example of this kind of modern project. It is challenging to draw the conclusion that such intentional attempts define missions, though. The macroeconomic environment must be stable, and there must be great coordination among the different government agencies, between the government and the private sector, between the government and the active state mode, and between the government and mission-driven policy making. Even though each of these sectors in Turkey has structural problems that are difficult to resolve quickly, mission-driven policy should be tested in specialized areas like the development of renewable energy.

A total of 363 enterprises have been formed to perform biotechnology operations, with DNA/RNA being the most employed technique and human health being the primary area of research, according to 2019 Biotechnology Statistics, published by TurkStat on 30 October 2020. TurkStat's Research and Development Activities Survey (2019), released on October 23, 2020, showed that R&D spending now accounts for 1.06% of the nation's GDP. TurkStat's 2020 Survey on Information and Communication Technology (ICT) Usage in Enterprises, published on August 28, 2020, showed that 94.9% of businesses have access to the internet. 53.7% of the businesses are online. 9.8% of people engaged in e-commerce, and 14.1% used cloud computing services. TurkStat's 2020 Survey on ICT Usage in Households and by Individuals, published on August 25, 2020, found that 79.0% of people use the internet, 51.5% use e-government services, and 36.5 use the internet to make purchases. According to TurkStat's Central Government Budget Appropriations and Outlays on R&D report from June 19, 2020, the central budget has allocated 14.9 billion TL (€2.8 billion) for R&D.

The Small and Medium Sized Enterprises (SME) Statistics 2019 show that SMEs account for 99.8% of all businesses, 72.4% of all jobs, and 36.6% of all exports. In Turkey's industrial sector, only 0.5% of SMEs use sophisticated technology in their operations. Low-tech and medium-low tech SMEs make up about 90% of the total SME population. However, in terms of absolute numbers, there are 2,153 SMEs that fall into the high-tech category. The total R&D spending by SMEs in 2019 was 9 billion Turkish Liras (approximately $1 billion), which represents about one-third of all company R&D spending in Turkey. On a full-time equivalent (FTE) basis, 112,338 people work in R&D in SMEs, which accounts for almost half (47.1%) of Turkey's overall R&D workforce. 345 SMEs registered patents in 2019. The success rates of medium-sized and even tiny businesses in securing patents are on par with those of big businesses. While SMEs submit around one in every four patent applications, major companies' patent applications are generally successful about 35% of the time. However, since only one out of every seven microbusiness patent applications are granted, special policymaking for these companies is necessary.

Any policy must be demand-driven and people-centric to be effective on the ground. The quality of human resources and the steps required to educate and develop them are therefore given the greatest priority under the current policy.

With separate sections on Service Conditions & Incentives for Scientific & Technical Manpower, Motivational Measures, and Science Popularization, the current strategy proposes an overarching framework of education and training of all types of individuals at all phases of life. A few recommendations have been made for improvement at various levels, including technical and vocational education, in-service training, non-formal education & training, and

the development of highly qualified S&T manpower. These recommendations take a holistic approach to education.

The nation's R&D infrastructure is focused on the supply side because there was no meaningful demand from industry. The industrial sector is thought to have very little R&D activity. In contrast, the industrial sector contributes significantly to the nation's overall R&D efforts in industrialized nations. Numerous actions for the Federal & Provincial Governments, R&D institutions, and industry have been suggested in the policy for improvements in the following areas in recognition of the urgent need to re-orient the public sector R&D organizations to demand-driven research in collaboration with the industry. Technology for Socioeconomic Development, Codification of Indigenous Knowledge, Management of Intellectual Property Rights Regime, Innovation Fund, Venture Capital and Equity Fund, and Incentives for Technology Development. The adoption of these suggestions is anticipated to promote domestic technological growth in the nation and foster R&D collaboration with industry.

International collaboration can enhance any country's S&T system and raise that country's capacity to contribute to the socioeconomic development of that country. It should go without saying that cooperation with industrialized countries is crucial for increasing technological proficiency. Working together with developing countries is essential because it allows for the discovery of best practices and easily included technology through sharing experiences with other countries at similar developmental stages. The policy recommends putting up a lot of effort to successfully cooperate with both developed and developing countries. Recommendations have been made in this regard to actualize the advantages of memorandums of understanding and agreements for both bilateral and multilateral cooperation. The nation's social, economic, and security interests must be taken into account while selecting thrust areas for research and development. The National ST&I Policy 2012 has identified 16 thrust areas for R&D activities in Pakistan and has provided methods to enhance efforts in each of these thrust areas.The focus areas include metrology, standards, testing and quality (MSTQ), energy, agriculture and livestock, biotechnology and genetic engineering, water, minerals, ocean resources, electronics, information and communication technologies (ICTs), space technology, materials science, nano science & nanotechnology, lasers & photonics, and engineering. The adoption of the ST&I Policy will create new opportunities for the development of engineering and research, the promotion of R&D organizations, fruitful collaborations between industry, academia, and R&D organizations, and, above all, the economic progress of the country.

Methodology:

Researchers that use interchange techniques are most often gathering and analyzing data from both qualitative and quantitative sources which they get from surveys, observations, interviews, document analysis, and/or numerical data. Various approaches (depending on the objectives as well as design of the research), can be adopted in any order. The following are some essentials of mixed methods research: In mixed methodology research, qualitative data’s are complemented by quantitative data through the integration, connection, or contrast of the findings from each approach. This coupling however may happen at any moment whether during data collection, processing, or analysis. Markers that cannot be exposed completely by a single methodological approach can be investigated adequately via the implementation of mixed methodologies. While the quantitative strategies permit generalization, analysis of statistics, and the representation of data with numbers, qualitative methods provide deep and precise observations of social phenomena, taking into account the richness of the situational context. Research using various methods may be implemented in sequence or resolved concurrently. A sequential design put one technique in place, used followed by another.

The process of data collection that takes place in mixed method research usually composes a combination of qualitative as well as quantitative techniques. The steps in data collection utilizing a mixed methodology approach are as follows: Identify the aims of the research: In chapter 2, the aims of the research are defined. Research questions requires both qualitative and quantitative methods to be used. The plan deals with such issue as identifying the quantity and quality of information which needs to be collected. The Figure 2.1 is depicted by research framework which suggests the layout for research studies and the sequencing of qualitative and qualitative methods in their unity. A sequential design is to cover two variants of data employs before and after the analysis.

Choose population: A case study is conducted by using two STI policies from two different countries: Turkey and Iran. For the interviewing process participants are chosen from three countries, which include Pakistan. Depending on the pre-set research goals, the purposive sampling and the convenience sampling are adopted in this research. Collecting qualitative data: The entire inventory is made up of non-quantitative data gathering activities, which include focus group discussion, interviews, and content analysis of STI policies and the interview transcripts. These qualitative data collection tools elicits profound, contextual information and it aligns with Science, Technology and Innovation Policy of Turkey, Iran and Pakistan. Collecting quantitative data: The data will be collected via an online or paper questionnaire serving as a governance instrument for analyzing the obtained data statistically to obtain numerical results. It deals with the technology transfer for many developing countries, including Pakistan that are aimed at strengthening their scientific, technology and innovation competencies to foster growth. As a result, relevant knowledge is acquired through Turkey's and Iran's STI policies, where it demonstrates the how their tactics, strategies, and results vary and are important for Pakistan to learn from. Learning how STI policies are interacting and affecting each other from the regional development perspective, draw a conclusion that these countries are very close to each other.

The comparison between Turkey and Iran on the particular levels of their socio-political, economic, and technological differences is always interesting. A study compared how different STI policies influence Pakistan, and that worth mentioned. Therefore grading these STI policies against 6 components and 22 policy interventions of the OMAR framework is another in its own. The fact that the subject matter has to do with how Pakistan might use features of Turkish and Iranian Governments in their own situation makes the issue more original. This research also covers issues that the run-of-the-mill policy analysis cannot resolve. The study should be up to date and come with a flavor of how current situation is if it considers the latest policy of Pakistan, Iran and Turkey.

Analysis

Table 4.1. Pakistan, Turkey and Iran policy statements illustrating presence of six STI policy components.

	Pakistan	**Turkey**	**Iran**	**Total**
International collaboration in STI	1	3	1	5
Policy for STI	16	19	19	54

STI and Community	4	7	8	19
STI and Governance	1	4	6	11
STI and Private sector	0	1	1	2
STI for Policy	21	10	9	40
Total	53	44	44	131

Above table is showing the comparison between Pakistan, Turkey and Iran with respect to the six components of the STI policy. It is found that for international collaboration Pakistan has made only 1 policy, Turkey has made 3 policies and Iran made only 1 policy. It shows that Turkey has more focus on international collaboration for STI in their country whereas Iran and Pakistan are at same level. For Policy for STI Pakistan has made 16 policies, Turkey has made 19 policies and Iran has made 19 policies, which shows that Turkey and Iran are more focused towards Policy for STI compared to Pakistan. For STI and community Iran has made highest number of polices which is 8, turkey has made 7 which is almost close to Iran and Pakistan has made only 4 policies. It shows that Iran and Turkey are paying more attention to developing STI for their community in their country whereas Pakistan is very steady in the race of creating this STI community.

Table 4.2:Annual Review of Pakistan, Turkey and Iran

Annual R & D		**Pakistan**	**Turkey**	**Iran**
R&D	2.6 billion	Less than require. status quo	65% larger than from Pakistan	52% larger than from Pakistan
PATENT		31	2121	2484
Entrepreneurial	42262 manufacturing industrial units 37347 small units 3598 Medium units 1317 Large units There are less than 20%			

The amount spent on research and development (R&D) each year varies greatly across Pakistan, Turkey, and Iran. However, it's crucial to keep in mind that the data may not be current given that my knowledge cutoff date is September 2021. Based on the data that is currently available, the following information about R&D investment in these nations:

1. Pakistan: Historically, Pakistan has maintained a low R&D investment to GDP ratio. The UNESCO Institute for Statistics estimates that Pakistan spent roughly 0.29 percent of its GDP on R&D in 2018 (the most recent year for which data are available). Although the government has been taking steps to boost R&D spending and encourage innovation, more work has to be done to raise investment in this field.

2. Turkey: To promote innovation and technical advancement, Turkey has recently made considerable investments in R&D. The Turkish Statistical Institute reports that in 2019, Turkey's R&D spending as a percentage of GDP was 1.06%. To enhance R&D spending, the government has set high goals, hoping to bring it to 3% of GDP by 2023.

3. Iran: As part of its ambitions for national development, Iran has placed a strong emphasis on R&D investment and innovation. The UNESCO Institute for Statistics reports that in 2018, Iran's R&D spending as a proportion of GDP was roughly 0.78%. The nation has been attempting to raise its R&D expenditures, with the aim of reaching 2.5% of GDP by 2025.

It's crucial to keep in mind that R&D spending by itself does not give an accurate picture of the research and innovation environment in a nation. The impact and results of R&D activities are also heavily influenced by factors including the efficiency of R&D investments, caliber of research institutions, collaboration between academics and industry, and the entire innovation ecosystem.

Table 4.3: R&D and Value

R & D	Last value	
R & D spending GDP	0.2	Percent
Researchers	383	
Pakistan R&D Workforce	18.75	Percent
Technician working in R&D	32	number per million
Articles in scientific and technical journals	12,904	
Increasing rate	12.34	Percent
Exports high-tech goods	318,589,665	US Dollar
Expected increasing	318	million US dollar
Manufactured exports	2	Percent

Many research projects are going to publication in a paper, and they are going to indicate top research areas, but they are unable to work through R&D, a major factor is that and some publications must accept beneficial for the maintenance of research and development areas. Lack of research is another major obstacle in our journey towards industrialization. Our

industries lake the financial resource to conduct research and development Pakistan's R&D spending as a percentage of GDP was unchanged from 2017 at 0.2% in 2019.

R&D spending as a percentage of GDP

Investments in creative effort conducted systematically to advance knowledge, including humanity's understanding of civilization, and culture, and the use of knowledge for new applications, are operating expenses (both public and private). Basic research, applied research, and experimental development are all included in R&D. Pakistan has 383 researchers per million inhabitants in R&D in 2019. From 157 researchers per million people in 2007 to 383 researchers per million people in 2019, Pakistan's R&D workforce rose at an average annual rate of 18.75%.

Researchers in R&D are experts who work on managing the tasks at hand as well as developing new ideas for information, things, procedures, or systems. Involved in R&D are postgraduate PhD students (ISCED97 level 6).

Pakistan has 32 (number per million) technicians working in R&D in 2017.

In Pakistan, there were 32 technicians per million persons in R&D in 2017. Despite significant recent fluctuations, Pakistani technicians in R&D tended to decline from 2005 to 2017, when they reached 32 technicians per million populations.

After exploring the three important dimensions of improvement from lessons learned in previous two objectives, the objective three has explored the institutional gaps that exist for each dimension of improvement explicitly. The key societal challenges discussed in chapter two have clearly mentioned the four areas which need concentration from the STI institutes in terms of strengthening the STI related capacities. The existing capacities in terms of human capital, R&D and entrepreneurial opportunities are explored for four key societal challenges (basic human needs, good governance, quality life and economic development). For every challenge, related to the distinct STI sector e.g. food, shelter IT, commerce etc., the existing strength in terms of human capital, R&D and entrepreneurial opportunities are explored along with the existing deficiencies for which STI system must develop the action plan. The large number of tables clearly proposed how much human capital is still required in these explicit STI fields, what kind of R&D is missing and must be addressed, and which kind of entrepreneurial opportunities exist. This objective, therefore, is a major direction for the Ministry of Science and Technology in Pakistan at the time of devising the action plan for the National STI Policy 2022.

Table 4.4: Mapping of SDGs and 22 STI policy responses

S.No	SDG	Description	22 STI Responses
1	4	Quality Education	02, 14
2	8	Decent Work & Economic Growth	01, 15, 22
3	9	Industry, Innovation & Infrastructure	03, 04, 05, 06, 07, 08, 13, 15, 16

4	12	Responsible Consumption & Production	01, 11
5	16	Peace, Justice & Strong Institutions	10, 18, 20, 21

Science, Technology, and Innovation (STI), if appropriately managed can play an important role in promoting inclusion and tackling Pakistan's socioeconomic difficulties. By establishing inclusive STI policies and efforts, the country can use its technological and innovative capacity to serve a broader spectrum of individuals, especially neglected communities. Here are some crucial points to consider when boosting STI inclusion in Pakistan:

Equal Educational Opportunity: Ensure that all students, regardless of gender, income, or geographic location, have access to high-quality STEM education. This can help to build a skilled workforce capable of contributing to innovation and advancement.

Gender Equality: To promote gender equality in the STI industry, encourage women's engagement in STEM education, research, and innovation. Remove barriers to women's engagement and provide supportive environments for their success.

R&D (Research and Development) for All: Encourage research on the needs and challenges of excluded populations. Encourage interdisciplinary research that combines traditional knowledge with current science to produce answers that are contextually appropriate and inclusive. Encourage the development and application of technology-driven solutions to social and environmental concerns such as clean energy, water access, healthcare, and agriculture. Assist businesses and entrepreneurs working on high-impact projects.

Remote and Rural Access: To close the digital divide, rural and remote people must have access to information and communication technologies (ICTs). Encourage projects that use technology to provide critical services to underserved communities.

Inclusive Innovation Hubs: Establish innovation hubs and incubators in various regions to provide training, mentorship, and resources to entrepreneurs from all backgrounds. These facilities can assist inventors in collaborating and networking.

Intellectual Property Rights (IPR) Awareness: Educate innovators, particularly those from underserved communities, on intellectual property rights and how to protect their discoveries. This enables people to market their ideas and earn from their labor.

Collaborations between the public and business sectors: Encourage relationships between the public and private sectors to promote inclusive STI. Encourage private businesses to invest in programs that benefit underserved communities while simultaneously satisfying their commercial goals.

Local Communities Should Be Involved: Local communities should be involved in the planning and implementation of STI projects. Make certain that their needs and opinions are included while building relevant and successful solutions. Create STI policies that explicitly stress inclusivity and equal access. Monitor and assess the impact of these policies on marginalized communities and make any necessary revisions.

Skill Development: Provide training and capacity-building programs that equip people from underserved communities with the knowledge and skills needed to participate in STI activities such as coding, entrepreneurship, and other relevant skills.

Data collection and analysis: Gather disaggregated data to better understand the impact of STI interventions on various demographic groups. This data can be used to guide evidence-based policies and efforts.

Table 4.5: Searching for inclusiveness and sustainability in STI policy responses

Content title	Review point
STI and inclusiveness	Create mentorship and support programs that encourage and inspire people to pursue professions in STI disciplines. Support research and projects that investigate the nexus of diversity and STI, with the goal of driving innovation through a range of viewpoints and experiences. Include cultural sensitivity and diversity principles in the design, development, and implementation of STI programs to ensure that they reflect and benefit all members of society.
Sustainability with STI	To solve environmental concerns and encourage responsible innovation, integrate sustainable approaches throughout STI research and development activities. Encourage STI stakeholders and sustainability specialists to work together to find new solutions for environmental conservation and resource management. Create financing channels and awards geared primarily at supporting STI projects that contribute to sustainability goals and address climate change and other aspects of sustainability.

STI Key Societal Issues and Challenges

Sustainability and Science, Technology, and Innovation (STI) are intimately related concepts that can mutually reinforce one another. Incorporating sustainability considerations into STI policies can aid in addressing global challenges, promoting responsible growth, and ensuring a better future. STI is lead to creative solutions to long-term concerns for example climate change, resource depletion, and pollution. Technologies and procedures created by STI can improve resource efficiency, reduce waste, and promote cleaner production. STI has the potential to accelerate the development and use of clean and renewable technologies including solar energy, wind power, and electric vehicles. These gadgets aid in the reduction of greenhouse gas emissions and the fight against climate change. STI can assist in the transition to a circular economy by developing methods to recycle and repurpose materials, reduce consumption, and create items with longer lifecycles.

STI can improve agricultural processes such as precision farming, crop breeding, and sustainable pest management, hence enhancing food security while lowering the environmental

impact of agriculture. Innovative STI solutions can help with water resource management and conservation, water quality improvement, and sanitation solutions, especially in areas where water is scarce. Advanced technologies can be used to monitor and manage ecosystems, track biodiversity, and prevent deforestation, all of which contribute to the conservation of natural habitats. By integrating efficient urban planning, green infrastructure, and smart transportation systems, STI can help cities become smarter and more sustainable. Advanced data analytics and modeling technologies can throw light on tough sustainability issues and aid in the implementation of evidence-based decision-making. Through education and awareness programs, STI may help individuals and communities understand and adopt more sustainable habits. STI can stimulate worldwide cooperation by exchanging knowledge, best practices, and technology to address global sustainability challenges. STI can assist strengthen resilience to natural disasters and climate-related events by building early warning systems, disaster response technology, and sturdy infrastructure. STI development should include ethical concerns to ensure that technological discoveries align with society values and promote equitable and just outcomes. Keeping all these under consideration tables 4.45 (a) to 4.45 (d) presets a mapping of the key societal challenges in Pakistan with the SDGs and the recommendations are drawn based on STI policy components and STI policy responses.

The objective four has finally presented a novel NASTIC framework based on four levels based on knowledge collection, knowledge exploration, knowledge analysis and knowledge creation. This objective presents a holistic approach for understanding the existing STI system in a country, followed by exploring strengths and weakness and accordingly devising the action plan. Resultantly contributing to the existing literature of the STI policy six components and 22 policy responses. After objective four the existing literature of Omar is enriched with the 3 new components and 2 new responses respectively. The added components include Sustainability and STI, Diversity and STI and Inclusiveness and STI.

Sustainability in STI entails ensuring that advances and developments in science, technology, and innovation relate to environmental, social, and economic well-being. In different industries in Pakistan, there is an increasing emphasis on sustainable practices. This involves encouraging the use of renewable energy, producing environmentally friendly technologies, and incorporating sustainability concepts into urban planning and infrastructure construction. Through innovation, efforts are being undertaken to lower industries' carbon footprints and encourage sustainable consumption and production habits.

Diversity in STI refers to the inclusion of people from varied backgrounds, such as gender, ethnicity, socioeconomic position, and others, in the processes of research, development, and innovation. In Pakistan, there is growing recognition of the value of diversity in fostering creativity and problem-solving in the STI sector. There are efforts underway to encourage more women and underrepresented groups to pursue professions in STEM fields. Diversity is increasingly being acknowledged as a source of strength that can lead to a greater range of opinions and ideas, ultimately driving innovation.

Inclusiveness in STI entails building an environment in which all individuals have equal access to opportunities, resources, and advantages in the field of science, technology, and innovation. Pakistan is working to diversify its STI ecosystem by improving educational opportunities, mentorship initiatives, and support networks for underrepresented communities. Efforts are being made to overcome the digital divide and guarantee that the benefits of STIs reach even the most rural and underserved places. To ensure that no one is left behind on the path to technological growth, inclusive policies are being devised.

Challenges and Prospects: While Pakistan is making strides toward incorporating sustainability, diversity, and inclusiveness into its STI landscape, there are still obstacles to overcome. Some of the challenges include a lack of money, outmoded infrastructure, and the need for more comprehensive policies. However, there is an increasing sense of urgency and acknowledgment of the significance of these ideas. Pakistan can nurture a healthy STI ecosystem that contributes to both technological innovation and societal well-being, while ensuring that the benefits are accessible to all sectors of the population, with sustained efforts.

Finally, Pakistan is gradually realizing the importance of including sustainability, diversity, and inclusiveness into its STI efforts. By cultivating an innovation culture that respects these ideals, the country may position itself as a contributor to the STI while solving significant socioeconomic and environmental concerns at national and international levels.

Conclusion and Finding

In Pakistan, Turkey, and Iran, there are numerous institutions which act at different stages in the policy life cycle of a STI (Science, Technology, and Innovation) policy, including formulation, adoption, implementation, and evaluation.

Findings for Pakistan:

The Ministry of Science and Technology created the STI policy after consulting with all relevant parties, such as government agencies, academic institutions, business associations, and research groups. The formulated policy goes through a review procedure before being submitted for approval to the appropriate government bodies, including the Cabinet or Parliament. The Ministry of Science and Technology oversees providing funds, creating programs, and carrying out the policy actions. R&D, innovation, entrepreneurship, and human resource development are all actively pursued in their programs. Data collection, performance indicators, and stakeholder feedback are used to assess the impact and efficacy of the policy. To review and amend the policy for continuous improvement, the evaluation results are employed. Though this entire process is adopted at the MoST, however, the findings clearly show a disconnect in different stages of the policy life cycle in the context of Pakistan. Though developing policy is evident but it is also evident policy implementation and evaluation has never been done. Therefore, STI system has struggled manifold in Pakistan.

Findings for Turkey:

The Ministry of Industry and Technology develops the STI policy in conjunction with stakeholders. The policy framework is formed after doing research, analysis, and consultations. The proposed policy must be approved by the appropriate government agencies, which could necessitate coordination across different ministries. The Ministry of Industry and Technology oversees this task, working alongside other governmental organizations, academic institutions, and business. R&D, innovation, industrial competitiveness, and capacity building are supported through actions. Performance measurement, economic impact analysis, and stakeholder engagement are used to gauge the effectiveness and impact of the policy. The evaluation's findings guide changes and advancements in policy.

Findings for Iran:

The Ministry of Science, Research, and Technology creates the STI policy with input from stakeholders. The process of formulating policies is informed by analysis, research, and consultations. The relevant government bodies, such as the Cabinet or the Supreme Council of

Science, Research, and Technology, study and approve the policy. In coordination with other government agencies, research organizations, academic institutions, and industry, the Ministry of Science, Research, and Technology carries out the policy's implementation. The growth of infrastructure, innovation, and global cooperation are all actively encouraged. Through outcome and impact assessments, performance evaluations, and stakeholder feedback, the policy's efficacy, outcomes, and alignment with national goals are assessed. Evaluation results direct policy revisions and alterations. The process of developing, enacting, implementing, and reviewing policies to support science, technology, and innovation is known as the "STI policy life cycle" in these countries. The success of the policies and their connection with changing needs and objectives must be ensured by constant monitoring, stakeholder involvement, and policy modifications.

Implications for Pakistan:

The study of evolution of STI system in Pakistan revealed that to address the key societal challenges presented in the National Science, Technology, and Innovation policy 2022 in Pakistan, policy-making institutes has played a critical role, however, a concrete action plan is still missing which needs an appropriate framework to strengthen the relevant human capital, research and development (R&D) projects, encouraging and facilitating the entrepreneurial opportunities. These institutes' who can contribute in devising the action plan can contribute in the following manner:

1. Setting priorities for national R&D: These can be done by the policy-making organizations like the Higher Education Commission (HEC), Ministry of Science and Technology and Planning Development. They evaluate social development issues and determine the most pressing needs for R&D. By establishing these objectives, policymakers at these institutions can direct the distribution of funds and encourage specialized research to address pressing issues.

2. Financing and Grants: Institutions that make policy can help Pakistani R&D ventures get financing and grants. They create tools and initiatives to help scientists, researchers, and inventors advance their work. These organizations support funding possibilities and financial resources, enabling R&D projects to successfully address key societal challenges.

3. Partnerships and Collaboration: To advance STI and address key societal challenges, policy-making organizations can support collaboration across the academic, industrial, and governmental sectors. Through programs including public-private partnerships, university-industry connections, and international cooperation, they can encourage partnerships. Policy-making organizations can harness knowledge, assets, and different viewpoints to foster innovation and tackle difficult problems by encouraging collaboration.

4. The development of human capital for STI is a key responsibility of policy-making institutions: They collaborate with colleges and research organizations to develop educational policies and initiatives that result in a trained labor force. To cultivate a pool of gifted researchers, scientists, and entrepreneurs who can contribute to R&D projects and address social concerns, they sponsor scholarships, fellowships, and capacity-building activities.

5. Support for Entrepreneurship: By fostering an atmosphere that is supportive of startups and innovation-driven businesses, policy-making organizations encourage the possibility of entrepreneurship. They provide frameworks and policies to promote entrepreneurship, including incubators, accelerators, and support systems for new businesses. These programs

aid in the conversion of research findings into marketable goods and services, fostering societal advancement and economic expansion.

6. IPR (intellectual property rights) and regulation: Establishing rules and procedures to safeguard intellectual property rights, patents, and innovation is the responsibility of policy-making organizations. They make certain that scientists and inventors have access to incentives and legal protection to market their work. Effective IPR regulations promote R&D spending, draw in domestic and international investors, and ease the knowledge transfer process.

7. Evaluation and Monitoring: Policy-making organizations are involved in assessing and keeping track of how R&D initiatives affect social advancement. They evaluate the results, efficiency, and applicability of R&D activities and base their recommendations on data and evaluation reports. Monitoring progress enables decision-makers to improve strategy, efficiently manage resources, and meet new difficulties.

Policy-making institutions in Pakistan actively shape policies and strategies to foster an environment that supports R&D initiatives, makes use of available human capital, and fosters entrepreneurial opportunities to meet major societal development concerns. They play a crucial part in creating an ecosystem where STI promotes growth in the economy, higher quality of life, and sustainable development.

Discussion

The holistic study of the STI evolution and role of institutions in Pakistan clearly depict that STI system is under threat because different public sector institutions are limiting access to material they own. Information access is critical to the efficacy of STI policies. Data silos within several public sector institutions might make it more difficult for policymakers to fully comprehend problems and establish the right goals for the STI sector's progress. In this scenario, the policymaking process is being examined. Good policies necessitate a thorough comprehension of the potential and problems facing the STI system. Making poor decisions can result from not having access to important information. The procurement, handling, and preservation of data necessitate substantial financial investments. This covers the price of technology, data processing equipment, and the labor needed for analysis. These budgetary difficulties might make it more difficult for the government to oversee the STI sector. Apart from monetary expenses, the procedure necessitates significant mental and physical exertion. Complex data analysis requires specialized expertise, and having the right physical infrastructure to store and process data is crucial. Appropriate prioritization requires an understanding of the data. It is hard to divide up resources and set development priorities if one does not have a thorough grasp of the STI sector's existing situation and the obstacles it faces.

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