ROLE OF SCIENCE AND TECHNOLOGY FOR NATIONAL PROGRESS, GROWTH AND COMPETITIVENESS

Organised by

NUST Institute of Policy Studies (NIPS)

WEBINAR Report

REPORT OF THE WEBINAR ON

THE ROLE OF SCIENCE AND TECHNOLOGY FOR NATIONAL PROGRESS, GROWTH AND COMPETITIVENESS

PREPARED BY

NUST INSTITUTE OF POLICY STUDIES

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- NUST Commandants, Principals, & Directors.
- Scientists, Researchers, Scholars, & Students.

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Executive Summary

NUST Institute of Policy Studies (NIPS) organized the webinar on role of science and technology (S&T) for national progress, growth, and competitiveness on Tuesday, July 28, 2020. The webinar brought together domestic and foreign experts to discuss and explore ways in which developing countries can utilize S&T for promoting economic and social development, fostering growth, and enhancing competitiveness. The speakers of the webinar comprised Dr Malcolm Parry OBE, Managing Director Surrey Research Park, Dr Kang Dachen, Professor, Institute of Policy and Management, Chinese Academy of Sciences (CAS), and Dr Masoom Yazinzai, Rector, International Islamic University Islamabad (IIUI). The webinar was chaired by Lieutenant General Naweed Zaman HI (M) (Retd), Rector NUST and Patron NIPS. The webinar was moderated by Dr Nassar Ikram, Pro-Rector, Research, Innovation and Commercialization (RIC), NUST, and Vice President National Science and Technology Park (NSTP). The webinar was attended by science policymakers, senior functionaries of Pakistan's national science, technology, and innovation system, local and foreign S&T experts, researchers, scholars, and students.

The webinar focused on the following question:

How can S&T be utilized by developing countries, especially Pakistan, for speedy, sustainable, and high-quality socioeconomic development and growth?

Following recommendations emerged from expert deliberations during the seminar:

1. S&T should be considered a strategic priority for national development and growth. As a strategic priority, at least 5-7 percent of GDP should be spent on S&T development including education.
2. A whole-of-system approach or the methodology of national system of innovation should be adopted for S&T development. Under this approach developing the individual elements and their mutual linkages should be equally important.
3. A 5-in-1 model of S&T development consisting of five key elements should be adopted, that is, according central position to S&T in national development planning and governance, promoting independent research and development, orienting S&T to directly support economic and social development, creating a strategic national S&T force consisting of the national academy of sciences, public research entities, and universities, and keeping pace with global S&T developments.
4. Comprehensive multi-domain, multi-sectoral, and multi-disciplinary national S&T development should be considered focusing on increasing both the quantity and quality of S&T talent in the country. The number of R&D and S&T personnel per million of population should be increased on urgent basis. The base salaries of young engineers, doctors, scientists, researchers, and technicians should be increased to make S&T an attractive career for the youth.
5. Strategic approach to university development should be prioritized. At least three top Pakistani universities should be selected for inclusion among the top 100 universities of the world by 2030.
6. R&D promotion should become a top priority focused on the promotion of high-quality basic research, the development of core technologies, and the enhancement of innovation performance, and increase in the quantity and quality of innovations. The national R&D agenda should include priority areas like IT-related technologies,

mineral processing and natural resources, emerging technologies, industrial biotechnology, nanotechnology, new energy storage systems, supercomputing and quantum computing, new nuclear energy systems, geothermal energy systems, synthetic biology, Artificial Intelligence (AI), robotics, etc. National R&D agenda should be promoted through prudent public-private partnerships.

7. Existing S&T infrastructure should be upgraded and new S&T infrastructure should be developed including the development of national large research infrastructures.
8. Integrated development of new industrial clusters like technology and business incubators, research parks, science and technology parks, high technology development zones, innovations districts, industrial parks, special economic zones should be prioritized and developed. Science-based development of national regions should be utilized to address various disparities and asymmetries.
9. Social capital creation for S&T development based on trust-based networks of creative reciprocity should be promoted to foster local scientific mobility and inland brain circulation.
10. Policies and initiatives across domains and sectors should be aligned and coordinated to reinforce national S&T development.

1. Introduction

Science and technology has been the key protagonist of the saga of modernization that began in the second half of the 18th century with the advent of the Industrial Revolution in England, and which continues to influence humankind for the better in myriad ways. From the latter half of the 18th century till date, four successive waves of modernization or four industrial revolutions have transformed global economy, politics, and society from their relatively crude factor-driven past to their highly sophisticated and complex technology-driven present. As we know, the first industrial revolution was powered by steam power, the second by electric power, the third by nuclear power, and the fourth industrial revolution is being currently driven by advanced information and communications technologies (ICTs), Artificial Intelligence (AI), and robotics. This signifies an exponential advancement of the S&T basis of each successive wave or revolution. Barring the haphazard and more or less private character of science and technology in the advancement of the 1st industrial revolution, the 2nd, 3rd, and 4th industrial revolutions largely involved major interventions and participation by the state on the one hand, and the growth of public-private partnerships for large-scale utilization of science and technology for national development and growth, on the other.

The role of science and technology in growth and competitiveness is correctly approached via the concept of knowledge economy, which captures the elements and linkages involved in this whole process of progress and growth. Knowledge economy refers to a system of consumption and production based primarily on intellectual capital and sources of knowledge rather than manual work, natural resources or even capital. The speedy development of knowledge economy with its four pillars, namely, favorable economic and institutional regime, human resource development, innovation, and advanced ICTs, has become the strategic priority for nations desirous of modernization, growth, and progress. Knowledge economy aims at the creation of the national systems of innovation which focus on the institutionalization of science and technology as well as the establishment of diverse spaces of innovation like startup accelerators, technology incubators, research parks, science parks, high technology zones, innovation districts, special economic zones, and industrial parks. The pride of place that science and technology enjoys in modernization, growth, and development is due to its dual significance because it serves both as the critical input and as one of the major outputs of development.

The following report is based on the critical analysis of the consolidated views of the speakers and participants.

2. Core Aspects of National S&T Development

2.1. S&T: A Strategic National Priority

S&T should be considered a strategic priority for sustainable national development. The first requirement for ensuring that S&T serves as a lever of innovation performance and national development is to make it the key part of the national development planning and strategy. Treating S&T planning as the key underpinning of development planning allows its integration across all the domains of development. Considering and utilizing S&T as the lever of development execution provides a unifying focus to the development efforts. Prioritizing and securing discretionary S&T funding as the fundamental guarantee of S&T development allows the optimal realization of the potential of S&T for growth and competitiveness.

Considering science, technology, and innovation (STI) as a strategic priority would allow the government, societal, public, private, and individual resources, resourcefulness, and ingenuity to be unlocked. Treating STI as an ad hoc second-tier item, as has been the default practice in most developing polities, would impair initiative and sow collective, individual, and institutional frustration. Strategic prioritization of S&T will directly reflect in the prominent position it will be given in national development agenda as determined by discretionary funding.

To say that S&T is a strategic priority and not give it at least 4 to 5 percent of GDP under normal circumstances would mean that it is not in actual fact a strategic national priority. The presence of other pressing issues in other domains should not be treated as a justification for providing strategic funding to S&T. It is a simple question of putting money where ones mouth is.

For the purpose of understanding the scale of urgency that is involved, it is important to understand that a day's delay in the strategic prioritization of S&T in the national development timeline means a year's delay in achieving growth and development. In order to develop into a comprehensive S&T power amidst the current urgent development conditions, Pakistan may have to spend at least 5 to 7 percent of GDP on science, technology, and innovation development. This includes but is not limited to the gross expenditure on research and development (GERD). The math is simple; the higher the priority of S&T in the estimation of the policymakers and decision makers, the greater the funding allocated for its development.

2.2. A Systemic Approach to S&T Development

Since the national S&T system is as good as its capacity to provide solutions to pressing economic, societal and security challenges so it is advised to develop S&T as part of the national system of innovation which consists of diverse but interconnected domains like government, universities, industry, and civil society. This approach is the comprehensive civilizational approach to development as it includes all major societal domains at the national level which can be scaled up to regional and global levels, and scaled back to subnational and local level.

The system thrives on continuous ever-changing and growing multidirectional flows between these domains based on open, purposive, and dynamic interaction among actors within and between these domains.

There is a natural fit between the strategic prioritization of S&T and the systemic approach to S&T development. Facilitating sustained and sustainable flows and interactions between actors within and between these domains is the multilevel challenge that determines the system's success, or lack thereof.

One of the key strengths of Pakistan has been the presence of relatively elaborate elements of national system of innovations. One of the key weaknesses of Pakistan's national system of innovation has been the weak state of linkages between these elements. The focus should be to develop both the elements and their linkages. It should be remembered that strengthening linkages between elements is also a robust way of developing elements themselves.

2.3. 5-in-1 Model of S&T Development[1]

The strategic priority and the systemic approach of S&T development can be fostered through the operationalization of the 5-in-1 model of S&T development and modernization. The model is based on the historical experience of the development of S&T with Chinese characteristics and consists of five prongs, namely, according central position to S&T in national development planning and governance, promoting independent research and development, orienting S&T to directly support economic and social development, creating a strategic national S&T force consisting of the national academy of sciences, public research entities, and universities, and keeping pace with global S&T developments. Needless to say, what is true of the system is also true of the model, that is, a high level of consistent, open, and dynamic interaction within and between the five prongs serves as the guarantee of the model's success.

The model is resilient and flexible and allows the navigation of national development through the time-honored five stages of economic growth as framed in the 1960s by the eminent economic expert W. W. Rostow, namely, traditional society characterized by subsistence agriculture and rudimentary technology, the preconditions for take-off characterized by the agricultural and primary industry development, take-off characterized by industrialization and technological breakthroughs, maturity marked by industrial diversification and extensive physical-social infrastructure development, and the period of high mass consumption characterized by technological sophistication and general prosperity. These stages of growth have provided a time-tested roadmap for the development execution.

Today, it is possible to identify a sixth stage of economic growth driven by domination of the economy by high-end services, robotics, Artificial Intelligence, internet of things (IoT), and digital transformation. Uneven global development of S&T in the last 100 years means that developing countries can now cover these stages much faster than old industrial nations did in the past. The 5-in-1 model provides the basis for sustaining speed and quality of growth and development by enabling countries both leapfrog whole stages altogether as well as accelerate the transition from the lower to the higher stages. This potential of S&T needs to be harnessed not only for sectoral but overall economic growth and development.

2.4. National S&T Talent Development

Promoting the comprehensive development of talent and taking the whole-of-economy and the whole-of-society approach for talent development is of the essence. The efforts of the Higher Education Commission, since its inception, to develop highly qualified talent in the country has been a crucial step in the right direction. However, the need of the hour is to foster the overall growth of all kinds of skill required for building the knowledge economy. This means improving the skills of workers, technicians, service-providers as well as enhancing existing professions and disciplines and creating new ones. Digital skills of the citizenry need to be upgraded across the board. Greater interface needs to be established between universities, research institutes, and public and private industrial enterprises.

[1] The model is based on China's experience of S&T development and was put forth in the presentation titled, "China's experience in Science and Technology Development and Its Policy Implications," delivered at the NIPS Webinar by Dr Kang Dachen, Professor, Institute of Policy & Management, Chinese Academy of Sciences (CAS).

Strategic industries need to be the focus of urgent talent development schemes by the government as these industries will perform the role of the vanguard of the fourth industrial revolution in Pakistan.

All levels of education, that is, primary, secondary, higher secondary, vocational and technical, and tertiary, need to be upgraded. Teacher training at all levels should also become the focus of comprehensive talent development. Developing talent should focus on cultivating world-class communication skills, analytical skills, and digital skills in addition to domain-specific or subject-specific technical skills. Learning by doing should become the standard method of instruction in both the industry and the university. There is an urgent need to increase the number of R&D personnel per million of population. In this regard, one measure that may be considered is to urgently increase the base salaries of young engineers, doctors, scientists, and researchers to make science an attractive career for the youth.

2.5. National University Development Program

Without the development of world-class universities, Pakistan cannot fulfil the dream of becoming a leading Asian nation. The S&T potential of the nation can only be realized optimally if there are leading universities to promote and spearhead R&D breakthroughs using traditional R&D mechanisms like disciplinary research and new mechanism like incubators and science parks. The policymakers should seriously consider championing at least 3 top Pakistani universities for inclusion in the top 100 universities of the world. This policy should be backed by clear guidelines and key performance indicators (KPIs) on the one hand, and sustained discretionary funding, on the other.

Several rounds of such university development can be put into action for developing the capacity of universities between 2020 and 2050. In these 30 years, three such rounds of university development can be run leading to the inclusion of at least 9 Pakistani universities in the top 100 universities of the world. Cluster approach should be promoted not only for industry but also for the educational sector. It needs to be understood that quantity is important as is quality. One is not the substitute of the other. The focus should, therefore, be on both at the same time. Scale economies in education will also help in generating quality.

2.6. National R&D Promotion

R&D promotion should be the national development priority and the guarantee for better and greater growth. This is what is meant by using S&T as the means and the end of development. S&T development leads to better and higher growth which in turn promotes greater quantum and quality of development. The focus of R&D promotion should be the promotion of high-quality basic research, the development of core technologies, and the enhancement of innovation performance, and increase in the quantity and quality of innovations.

In this regard, the priority areas, namely, technical training, innovation and entrepreneurship initiatives, high value-added agriculture, IT-related technologies, mineral processing and natural resources, emerging technologies, industrial biotechnology, nanotechnology, 3D printing, energy storage systems, etc., as identified by the Prime Minister's Task Force on Technology-Driven Knowledge Economy should be promoted in public and private sectors in industry and academia alike.

Areas like supercomputing, space science and technologies, marine technologies, new nuclear energy systems, geothermal energy systems, Artificial Intelligence (AI), robotics, and synthetic biology should also be introduced into the national R&D agenda guiding the efforts of public and private domains.

2.7. S&T Infrastructure Development

Existing national S&T infrastructure should be upgraded and new S&T infrastructure should be developed in order to carry out successfully the R&D promotion as mentioned above. This should involve carefully selected public and private partnerships aimed at renewing existing S&T infrastructure as well as building new R&D infrastructure. Pakistan should also focus on the development of large research infrastructures.

In this regard, the concept of the national large infrastructures as defined by the Chinese Academy of Sciences can help the policymakers of developing nations to formulate, develop, and sustain a strategic S&T focus for comprehensive national development:

> The national large research infrastructures refer to the large facilities for scientific and technological research built with the investment made by the government and shared in their long operation by the S & T community in order to make important breakthroughs and solve the strategic, basic and forward-looking scientific and technological problems in economic and social development as well as the security of the country.[2]

In the long run, the development of national large research infrastructures ultimately underpin the national sovereignty and help indigenize national security and defense. These infrastructures, as defined above, reduce dependence on external sources and promote interdependence. CPEC has provided Pakistan with a great opportunity and the possibility of channeling the funding to support the development of national large infrastructures may also be explored.

However, the best option is to develop these infrastructures with own national funds. The instrument of tax should be considered for this purpose by communicating the urgent need of this kind of development to the nation by taking it in confidence.

2.8. New Industrial Cluster Development

Technology and business incubators, research parks, science and technology parks, high technology development zones, innovations districts, industrial parks, and special economic zones should be prioritized and developed. All S&T universities should be encouraged to establish their technology incubators or science parks. These innovation spaces should become the bridgehead for collaboration with industry.

The government should take an S&T approach to regional planning and developing. Science-based regional development should center on the development of universities and new industrial clusters as a means of regional regeneration, modernization, growth, and development. This approach should be especially useful for developing and upgrading

[2] Hesheng Chen ed, *Large Research Infrastructures Development in China: A Roadmap to 2050* (Beijing & Heidelberg: Science Press & Springer, 2011), 5.

Pakistan's medium-sized, second-tier cities. This approach should also help in rationalizing Pakistan's urbanization trend that is focused on a few big cities alone.

The focus of new industrial cluster development should be to promote different kinds of innovation such as product, process, service, organizational, marketing, management, pro-poor inclusive and social innovation.

Development of science parks can help realize Pakistan's potential for S&T-led innovation and speedy growth as they can provide the breakthrough in the much-needed modernization and new growth in Pakistan. This transformation requires a spirit of open innovation and multi-dimensional collaboration among key stakeholders.

Science parks need to facilitate three interrelated journeys for the growth of startups into profitable businesses, namely, technology journey from the idea to the market, the market journey based on finding customers critical to success, and the regulation journey based on legal activity promotion and investor-friendly tax regulations.[3]

2.9. Social Capital for S&T Development

Open collaboration and willing participation should be the guiding spirits of the nation-wide process of S&T development. S&T institutions, including the universities, need to create not only greater quantum of intellectual capital but also greater sum of social capital.

For instance in so far universities are concerned, trust-based networks of creative reciprocity between their workforces and student populations should be promoted so that increased inter-university collaboration could contribute the process of S&T-based development of the country.

This would provide a powerful values-based incentive for S&T promotion. One of the positive outcomes of science-based social capital development will be an increased domestic scientific mobility critical for exchange of knowledge and experience.

It also needs to be remembered that brain drain is not only an inter-state phenomenon. Something analogous also takes place domestically. Through inland brain circulation, social capital developed as proposed herein can address the effects of domestic brain drain in which there is flight of talent from less to more developed regions inside the country and from less developed to more developed institutions.

2.10. Policy Mix for STI Promotion

STI promotion requires a new approach to policymaking and greater policy alignment across several domains. Policies and funding allocation across different domains should be done in such a manner that they lead to greater STI promotion. This means that policies cannot afford to be made in isolation from each other.

The impact of policies in one domain of necessity impacts the speed and scale of development in the other. It also means that both fiscal and monetary instruments need to be used together for STI promotion. This approach agrees with the national-system-of-innovation approach for national development and growth.

[3] The idea of three journeys was put forward by Dr Malcolm Parry OBE, Managing Director, Surrey Research Park, University of Surrey, United Kingdom, in his presentation, titled, "The Role of Science and Technology for National Progress and Competitiveness," at the NIPS Webinar. The idea is based on Dr Parry's long experience in successful science park development and management.

3. Recommendations

Based on the foregoing critical reflections, following recommendations are proposed:

11. S&T should be considered a strategic priority for national development and growth. As a strategic priority, at least 5-7 percent of GDP should be spent on S&T development including education.
12. A whole-of-system approach or the methodology of national system of innovation should be adopted for S&T development. Under this approach developing the individual elements and their mutual linkages should be equally important.
13. A 5-in-1 model of S&T development consisting of five key elements should be adopted, that is, according central position to S&T in national development planning and governance, promoting independent research and development, orienting S&T to directly support economic and social development, creating a strategic national S&T force consisting of the national academy of sciences, public research entities, and universities, and keeping pace with global S&T developments.
14. Comprehensive multi-domain, multi-sectoral, and multi-disciplinary national S&T development should be considered focusing on increasing both the quantity and quality of S&T talent in the country.

    The number of R&D and S&T personnel per million of population should be increased on urgent basis. The base salaries of young engineers, doctors, scientists, researchers, and technicians should be increased to make S&T an attractive career for the youth.
15. Strategic approach to university development should be prioritized. At least three top Pakistani universities should be selected for inclusion among the top 100 universities of the world by 2030.
16. R&D promotion should become a top priority focusing on the promotion of high-quality basic research, the development of core technologies, and the enhancement of innovation performance, and increase in the quantity and quality of innovations. The national R&D agenda should include priority areas like IT-related technologies, mineral processing and natural resources, emerging technologies, industrial biotechnology, nanotechnology, new energy storage systems, supercomputing and quantum computing, new nuclear energy systems, geothermal energy systems, synthetic biology, Artificial Intelligence (AI), robotics, etc. National R&D agenda should be promoted through prudent public-private partnerships.
17. Existing S&T infrastructure should be upgraded and new one should be developed. This should also include the development of national large research infrastructures.
18. Integrated development of new industrial clusters like technology and business incubators, research parks, science and technology parks, high technology development zones, innovations districts, industrial parks, special economic zones should be prioritized and developed. Science-based development of national regions should be utilized to address various disparities and asymmetries.
19. Social capital creation for S&T development based on trust-based networks of creative reciprocity should be promoted to foster local scientific mobility and inland brain circulation.
20. Policies and initiatives across domains and sectors should be aligned and coordinated to reinforce S&T development.

4. Conclusion

The growth and development of all the leading nations of the world, the newly industrialized countries, and emerging economies has rested on deploying S&T as a major lever of development, a major component of the knowledge economy framework and the national system of innovation. Pakistan has not fared well historically in this domain due to low levels of investments, particularly in education, research and development, restricted digital access, and an unenvious track record of goal-oriented institutional collaboration. Pakistan all along has had all the elements involved in S&T- based development and modernization but it has not been particularly successful in promoting linkages and flows among these elements. It is now at a juncture where it has to make right decisions aimed at achieving a paradigm shift. In this regard, the great opportunity for comprehensive development provided by CPEC should also be utilized for optimal outcomes in S&T development and innovation performance enhancement. In fact, in the wake of the COVID-19 pandemic, the importance of science and technology has become even more pronounced and urgent. The global disruption in economy, trade, higher education, and globalization can only be offset and reversed in the short and the long run through S&T-driven research, development, and innovation. In this regard, competitiveness and progress in the post-COVID-19 era will only belong to those nations that successfully leverage knowledge as the predominant factor of growth.