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Mapping Research and Innovation in the Republic of Uzbekistan

GO→SPIN Country Profiles in Science, Technology and Innovation Policy

Volume 10

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In cooperation with the Ministry of Innovative Development of the Republic of Uzbekistan

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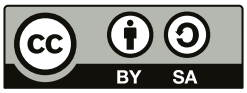

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Acronyms and abbreviations

AI	Artificial intelligence
CAT	Centre for Advanced Technologies
CER	Centre for Economic Research
CIS	Commonwealth of Independent States
ESP	Education Sector Plan
FDI	Foreign direct investment
FEZ	Free economic zones
FTE	Full-Time equivalents
GDI	Gender Development Index
GDP	Gross domestic product
GERD	Gross domestic expenditure on research and development
GII	Gender Inequality Index
GNI	Gross national income
GO→SPIN	Global Observatory of Science, Technology and Innovation Policy Instruments
HDI	Human Development Index
ICT	Information and communication technologies
IsDB	Islamic Development Bank
IsDBG	Islamic Development Bank Group
IFC	International Financial Corporation
ILO	International Labour Organisation
IP	Intellectual property
IT	Information technologies
M&E	Monitoring and evaluation
MIT	Massachusetts Institute of Technology
MoID	Ministry of Innovative Development
NAPM	National Agency for Project Management
NGO	Non-Governmental organization
NIS	National innovation system
OECD	Organisation for Economic Co-operation and Development
PPP	Purchasing power parity
R&D	Research and development
RI	Research institute
S&T	Science and technology
SAGA	STEM and gender advancement
SDGs	Sustainable Development Goals
SEZ	Small economic zone

SME	Small and medium enterprise
SSR	Soviet Socialist Republic
STEM	Science, technology, engineering and mathematics
STI	Science, technology and innovation
SWOT	Strengths, weaknesses, opportunities and threats
TISCs	Technology and innovation support centres
TTO	Technology transfer office
TUIT	Tashkent University of Information Technologies named after Muhammad Al Khorezmiy
TVET	Technical and vocational education and training
UAE	United Arab Emirates
UIS	UNESCO Institute for Statistics
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFPA	United Nations Population Fund
USD	United States dollar
USSR	Union of Soviet Socialist Republics
WIPO	World Intellectual Property Organization

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Foreword by the Assistant Director-General for Natural Sciences, UNESCO

Shamila Nair-Bedouelle © UNESCO

We live in a rapidly changing environment, where science, technology and innovation (STI) have a vital role to play in achieving the 2030 Sustainable Development Agenda and the Sustainable Development Goals (SDGs).

The 2019 Global Sustainable Development Report *The Future is Now: Science for Achieving Sustainable Development* reminds us that in order to help policy-makers develop and use the full potential of STI, we need evidence and tools to understand the complexities, dynamics and evolving environment of national STI systems.

International scientific cooperation is vital for accelerating progress towards the SDGs, which is why UNESCO, in cooperation with development partners and UN agencies, has strengthened its efforts to reinforce STI systems and the sharing of best practices.

Through its 'Mapping Research and Innovation' series, UNESCO has accompanied several Member States to analyse and review their national STI policy systems, and to reflect on the challenges, strengths and opportunities for improving STI governance. The reports in this series aim not only to improve policy-making, implementation and evaluation, but also to align STI to national development needs and objectives.

The Republic of Uzbekistan is highly committed to strengthen STI and the government has set ambitious goals to deploy STI as drivers for socio-economic development in the country. This report reviews different dimensions of the STI system of Uzbekistan, covering its legal framework, operational policy instruments in place, coordination and organizational structures, and provides a series of policy recommendations for future actions.

The report is the fruit of a successful cooperation between the Government of Uzbekistan, the Islamic Development Bank (IsDB) and UNESCO. The participation and contribution of various STI stakeholders in the country, together with the financial support of the IsDB, made these last two volumes possible, for which I am deeply grateful.

I am confident that this new volume in UNESCO's series 'Mapping Research and Innovation' will provide the Republic of Uzbekistan, policy-makers and the global scientific community with useful guidelines for inclusive, evidence-based STI policy.

Shamila Nair-Bedouelle
Assistant Director-General for Natural Sciences, UNESCO

Foreword by the Senior Advisor to the IsDB President for Science, Technology and Innovation

Hayat Sindi © IsDB

We at the Islamic Development Bank pride ourselves on placing STI at the heart of the development agenda for the member countries. This is exemplified by the IsDB President's 5-year Program (P5P) which transforms the Bank from a financier to knowledge-based organization that partners with MCs and proactively supports them to address their most pressing socio-economic challenges through innovative and sustainable solutions.

STI-based policies are continuously recognized as strategic drivers of economic growth. With the right tools and convenient environment, innovators and the business community can tap on the potential of STI to develop innovation solutions for the development issues facing their communities, through boosting skills, sourcing ideas and knowledge transfer.

In this context, we forged a unique partnership with UNESCO to strengthen the STI Policymaking cycle and reinforce the capacity of Uzbekistan to develop, implement and monitor gender-responsive STI policies. This Publication, the GO→SPIN Country Profile, lays the foundation to achieve this and provides a better understanding of the STI country ecosystem by identifying specific challenges, strategic areas of investment, and their alignment to the national development agenda. The profile will help Uzbekistan to develop an overarching national STI Policy, strengthen capabilities to produce accurate STI information for evidence-based decision making.

I would like to congratulate the Government of Uzbekistan for pioneering this initiative and I am confident that Uzbekistan investment in STI will create innovative solutions for the development challenges and thus the country will be a model for inspiration to other countries in the region. I would like also to thank UNESCO for joining efforts with IsDB to strengthen the STI systems of Member Countries through providing the appropriate methodology, technical assistance, and training. Special appreciation is extended to staff in the STI department whose tireless efforts and substantial contribution led to the production of this report.

I would like to express my sincere gratitude to H.E. Dr. Bandar Hajjar for his visionary leadership in promoting STI to support MCs to tackle global development challenges.

Hayat Sindi
Senior Advisor to the IsDB President for Science, Technology and Innovation,
General Supervisor of Communications and External Relations.
UNESCO Goodwill ambassador for Science.

Science, Technology and Innovation: driving force of social and economic progress

Dr Ibrokhim Y. Abdurakhmonov, Minister of Innovative Development

Dr Ibrokhim Y. Abdurakhmonov
© Ministry of Innovative Development

The wave of the fourth industrial revolution in the world is forcing countries to adapt, develop and spread technologies and innovations within and beyond their borders. Disruptive innovation is the answer to sustainable and inclusive economic growth, inclusive society and the overall welfare of states.

Innovation is a driving force of social and economic progress. The President of the Republic of Uzbekistan, Shavkat Mirziyoyev, noted 'Today, we set out on an innovative path of development, aimed at comprehensive improvement of all spheres in government and society. If we start building our great future today, we build it a foundations of innovative ideas and innovative approaches'.

Ambitious market reforms led by the Government are creating favourable conditions for science, technology and innovation development. The Government prioritizes the importance of utilizing and disseminating innovation and scientific results throughout the economy to improve the welfare of the population and raise the level of human capital, increase efficiency, effectiveness and quality of production. A lot of work has been done through the joint efforts of various innovation system actors to strengthen STI policy and more is yet to be done.

We are grateful to UNESCO and the Islamic Development Bank for assisting us in this important transformation process and leveraging the best international practices to build a balanced national policy for supporting STI. We are certain that our joint work will bring an important contribution in building a sustainable science, technology and innovation system in Uzbekistan.

Dr Ibrokhim Y. Abdurakhmonov,
Minister of Innovative Development of the Republic of Uzbekistan,
Doctor Of Sciences in genetics and molecular genetics

Executive summary

This report presents the Science, Technology and Innovation (STI) country profile of the Republic of Uzbekistan, conducted by UNESCO for the Government of Uzbekistan and the Islamic Development Bank (IsDB). The study, published as volume 10 in UNESCO's series, draws on UNESCO's Global Observatory of Science, Technology and Innovation Policy Instruments (GO→SPIN) methodology, a tool developed to analyse national STI systems.

The IsDBG recognizes that STI is imperative for sustainable and inclusive development of its member countries and Muslim communities in non-member states, as well as for the achievement of the Sustainable Development Goals (SDGs). Hence, it is committed to provide support to eradicate poverty, develop new and more sustainable ways to satisfy needs, and empower women and men to transform their lives for the better through STI.[1]

Uzbekistan is a lower middle-income country with 32,656,700 inhabitants and a GDP per capita of USD 1,532.4 in 2018.[2] Around 60% of the population is under the age of 30 years and 35% of the population is below 16 years old. Half of the population in the country lives in urban areas.

Over the last three years, Uzbekistan has gone through an economic transformation to stimulate social and economic development. Since the country gained independence in 1991, the leadership changed for the first time at the end of 2016 with the election of the new president. After assuming office, President Shavkat Mirziyoyev initiated reforms to establish a market-oriented economy and improve the business and investment climate. STI plays a significant role in this process and there is a strong political will and high-level commitment to achieve innovation-driven development.

With the impetus given by the reforms, real GDP increased by 5.1% in 2018 compared with an increase of 4.5% in 2017. The economic growth continued steadily during the first three quarters of 2019 at 5.7% year on year.[3] In spite of the economic growth, the unemployment rate – particularly youth unemployment – remains high. According to the World Bank, 10.3% of the total labour force between 15–24 years of age is unemployed in 2019, while total unemployment is at 5.5%.[4] The skills gap and mismatch in the labour market, and limited supply of training in technical skills are the challenges that have impacted unemployment. Although Uzbekistan's Human Development Index (HDI) score has increased from 0.595 to 0.710 between 2000 and 2017,[5] owing to the increase in life expectancy at birth and improved schooling, poverty is still an issue. Some 11.4% of the population (75% of whom live in rural areas) live below the national poverty line. Also, 27.7% of the employed population earn less than USD 1.90 (PPP) per day.[6]

With regard to the female labour force, Uzbekistan has the second highest rate of female participation in Central Asia (with a female-to-male labour force participation rate of 68.5% in 2018). The government is committed to increasing women's participation in public and political life to achieve the SDGs. As a result

1 Institutional STI Policy for the IsDBG, 2018
2 https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=TJ-UZ-KG-TM-KZ
3 World Bank and EBRD data
4 https://data.worldbank.org/indicator/SL.UEM.1524.ZS?locations=UZ
5 http://hdr.undp.org/en/countries/profiles/UZB - Human Development Indices and Indicators: 2018 Statistical Update
6 https://data.adb.org/dataset/basic-statistics-asia-and-pacific

of recent efforts, 25% of parliamentary seats are held by women and the share of women senators is 32%. However, women are under-represented in the private sector (only 36% and 25% of full-time workers in medium and large enterprises, respectively, are women).[7]

The government endorsed the Sustainable Development Goals (SDGs) in 2015. Sixteen national SDGs with 127 related targets were adopted by the government in October 2018. The Coordination Council was established, a roadmap was developed, and a web portal was created for implementing and monitoring the SDGs.[8]

The gross domestic expenditure on research and development (GERD) as a percentage of GDP in Uzbekistan is quite low and stood at 0.2% between 2008 and 2017, according to the UNESCO Institute of Statistics (UIS). The number of researchers has slightly changed in the same period and stood at 496.34 per million inhabitants (full-time equivalent) in 2017. On the other hand, progress has been achieved in STI outputs: the number of patents filed rose from 239 in 2009 to 480 in 2018,[9] and the number of scientific and technical journal articles increased from 278 in 2003 to 357 in 2016.[10]

The current STI policy of Uzbekistan is defined in the Presidential Decree 'On Approval of the Strategy for Innovative Development of the Republic of Uzbekistan for 2019–2021'.[11] Adopted in September 2018, the strategy sets ambitious goals for the enhancement of STI: placing the country among the top 50 economies in the Global Innovation Index by 2030; quadrupling the GERD from the current 0.2% of GDP to 0.8% of GDP by 2021; improving scientific excellence, and strengthening the links between education, science and industry; and placing the universities among the top 1,000 universities in international rankings.

With the new policy, which places innovation at the heart of the development process, the actions to create a robust national innovation system (NIS) have recently been initiated. An important step has been the creation of the Ministry of Innovative Development (MoID) in November 2017 to lead the implementation of the STI policies and policy instruments. Furthermore, the Republican Council on Science and Technology was established with Decree No. 953, issued on 27 November 2019, as an advisory body for the development of S&T and the improvement of higher education. Several other elements of the NIS are also in place but the transformation process within the system is still ongoing. At the same time, important actions are being taken to reinforce the system, such as the enhancement of the infrastructure and improvement of working conditions in the Academy of Sciences, and advancement of the status of researchers. Since 2018, nearly USD 7 million was invested in upgrading the laboratories of the Academy's research institutes.

To support the implementation of STI policies and strategies, a number of decrees have been issued since 2017. A significant recent development in the legal framework has been the endorsement of the law 'On Science and Scientific Activities' in 2019. A similar law for innovation activities was drafted and is expected to be approved by the parliament.

There are several direct and indirect STI policy instruments implemented in the country. Existing policy measures are directed towards the creation of start-ups, development of human capital for research and research commercialization. The MoID manages two funds to support STI in the country: the 'Fund for Supporting Innovative Development and Innovative Ideas' and the 'Presidential Fund for the Commercialisation of the Results of Scientific and Scientific-Technical Activities'. There is also an international internship scheme, launched two years ago for young researchers. Indirect measures include the fiscal incentives offered in technology parks and other innovation infrastructures. Attempts to commercialize research results from research institutes have as yet been unsuccessful due to limited capabilities, knowledge and experience in the valuation of intellectual property and the management of the negotiation process with potential technology buyers.

7 ADB, 2019
8 http://nsdg.stat.uz/
9 https://www.wipo.int/ipstats/en/statistics/country_profile/profile.jsp?code=UZ
10 https://data.worldbank.org/indicator/IP.JRN.ARTC.SC
11 https://lex.uz/docs/3913186

As Uzbekistan moves towards creating an innovation-driven economy, it needs to build up a fully-fledged NIS, pursue more effective STI governance, create a balanced STI policy mix and continue to invest in building STI capacities. The main needs and opportunities relating to these elements, based on the desk and field research conducted under this study, are explained in the fifth section of this report. Taking into account the developments and achievements from the last three years, and considering the opportunities and needs identified, a set of recommendations are proposed to the government to support the process of transformation to an innovation-driven economy.

Among them, the following are considered as priorities (the full list of recommendations is given in the seventh section of the report):

a. Reviewing and revising the legislation of the Republican Council on Science and Technology to empower it as a high-level institution for the coordination of the formulation and implementation of STI policies, establishment of multi-stakeholder dialogue, design of a coherent STI policy mix, and integration of STI in other policy areas.

b. Appointing the MoID as the secretariat organization of the Council for the effective management of the STI policy cycle from design to evaluation, ensuring transparency and accountability of the public support for STI, and eliminating any potential conflict of interest and overlaps in the system.

c. Designing a fully-fledged STI policy for the next ten years with the active involvement of the NIS stakeholders.

d. Creating two autonomous programme implementation institutions in the form of a national innovation agency[12] and a national science agency[13] for the design and implementation of innovation and research policy instruments, respectively, and ensuring that the top-level project selection committees of these agencies predominantly include high-level international experts in order to fund high-impact projects with potential to be commercialized at international level.

e. Redistributing the roles and responsibilities among the NIS stakeholders involved in the implementation of policies, strategies and measures for innovative development, taking into account principles such as segregation of duties, transparency and effective coordination.

f. Establishing and maintaining a balanced policy mix, and evaluating and improving the existing STI instruments and STI infrastructures to achieve greater and sustainable impact, and eliminate duplications.

g. Strengthening the research institutes (RIs), particularly those of the Academy of Sciences, by implementing a comprehensive reform programme.

h. Establishing clear definitions for the concepts that concern STI policies and creating a common understanding about them among all actors of the system.

i. Developing and implementing measures to continuously invest in skills and capacity building for teams responsible for policy, project and programme design and implementation at the ministries and other agencies (including the management units of innovation infrastructures).

12 Examples of such agencies to design and implement public support programmes to promote innovation can be found in a large number of developed and developing countries, such as VINNOVA in Sweden, Innovate UK, Innosuisse in Switzerland, Enterprise Estonia, and MITA in Lithuania.

13 Some examples of national science agencies are NSF in the USA, ARC in Australia, ANR in France, JST in Japan and SFI in Ireland.

Acknowledgements

Mapping Research and Innovation in the Republic of Uzbekistan is the outcome of a collaboration between the Ministry of Innovative Development of the Republic of Uzbekistan and UNESCO (Tashkent and Almaty offices; and the Division of Science Policy and Capacity-Building, based at the UNESCO headquarters in Paris).

Our sincere thanks go to the Islamic Development Bank (IsDB) for its financial support in the preparation and publication of this volume. We would like to thank Dr Hayat Sindi, Senior Advisor on STI to the President of IsDB, and Mr Mohamed Shaker Hebara, Strategy Division Manager in STI, for their great support.

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In particular, we would like to thank the author of the present volume: Sirin Elci, International STI policy expert and President of INOMER, who conducted a policy analysis of the STI innovation system of Uzbekistan to produce this informative study.

Peggy Oti-Boateng
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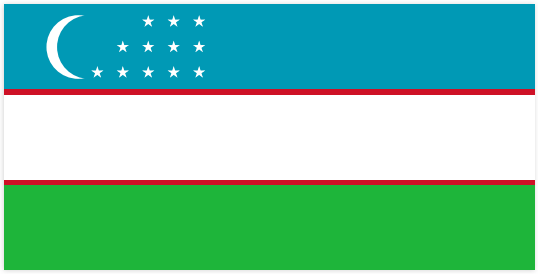
UNESCO

1. Uzbekistan: Mapping the STI landscape



Official name	The Republic of Uzbekistan (Independence from the Union of Soviet Socialist Republics (USSR) on 31 August 1991)
Capital city	Tashkent
Region	Europe and Central Asia
Income level	Lower-middle income
Population	32,656,700 inhabitants[14]
Total area	447,400 km^2 [15]
Chief of State	Shavkat Mirziyoyev (second president of the country, officially elected on 14 December, 2016)
Head of government	Abdulla Aripov (deputy prime minister from 2002–2012 and again in 2016)
Elections/ appointments	The president is elected by the citizens of the Republic of Uzbekistan, based on the universal, equal and direct suffrage by secret ballot, for a term of five years. The president appoints the prime minister and the government must be approved by the Oliy Majlis (parliament).
Legislative branch	The Oliy Mailis is the Uzbek supreme state representative which exercises legislative power. It is composed of 150 elected deputies. It consists of two chambers – the Legislative Chamber (the lower chamber) and the Senate (the upper chamber). The term of power of the Legislative Chamber and the Senate of the Oliy Majlis of the Republic of Uzbekistan is five years
Ethnic group	More than 100 ethnic groups live on the territory. The native inhabitants are Uzbeks, who make up about 80% of the population
Languages	Uzbek (official), Russian and various ethnic languages
Main religion	Islam (mostly Sunni)
Unit of currency	Uzbek som
Independence day	1 September, 1991
Date of constitution	8 December, 1992

1.1. INTRODUCTION

This report presents the Science, Technology and Innovation (STI) country profile of the Republic of Uzbekistan conducted by UNESCO for the Government of Uzbekistan and the Islamic Development Bank (IsDB). The study mainly draws on UNESCO's Global Observatory of Science, Technology and Innovation Policy Instruments (GO→SPIN) methodology, a tool developed to analyse national STI systems (see Annex).

The IsDBG recognizes that STI is imperative for sustainable and inclusive development of its member countries and Muslim communities in non-member states, as well as for the achievement of the Sustainable Development Goals (SDGs). Hence, it is committed to provide support to eradicate poverty, develop new and more sustainable ways to satisfy needs, and empower women and men to transform their lives for the better through STI.

14 From 2019, ADB – basic statistics https://data.adb.org/dataset/basic-statistics-asia-and-pacific
15 ADB, 2019

The report is made up of seven sections: After a brief introduction below, an overview of the contextual background is given in the second section. The third section describes the current status of the STI system and policy framework in the country. Section four describes the operational STI policy instruments in Uzbekistan, followed by a preliminary review of the needs and oportunities for STI development in section five. An analysis of the STI-related strengths, weaknesses, opportunities and threats (SWOT) for Uzbekistan is given in the sixth section. Section seven provides a brief summary of conclusions as well as the recommendations formulated for the Government of Uzbekistan. A glossary of STI-related concepts used in this report is given at the end.

1.1.1. Background

Uzbekistan is a lower middle-income country with 32,656,700 inhabitants and a gross domestic product (GDP) per capita of USD 1,532.4 in 2018.[16] Around 60% of the population is under the age of 30 years and 35% of population is below 16 years old. Half of the country's population live in urban areas.

Over the last three years, Uzbekistan has undergone an economic transformation to accelerate development. Since the country gained independence in 1991, the leadership changed for the first time at the end of 2016 with the election of the new president. After assuming office, President Shavkat Mirziyoyev initiated reforms to establish a market-oriented economy and improve the business and investment climate. STI plays a significant role in this process, and there is a strong political will and high-level commitment to achieve innovation-driven development (see Annex).

BOX 1 – 2020: THE YEAR OF DEVELOPMENT OF SCIENCE, EDUCATION AND THE DIGITAL ECONOMY IN UZBEKISTAN

In his address to the Parliament on 24 January 2020, President Shavkat Mirziyoyev declared 2020 as the 'Year of Development of Science, Education and the Digital Economy'.

He stated: 'Science and education are of paramount importance for enhancing the intellectual and spiritual potential of young people as much as our entire society. Societies failing to promote science suffer regression and backwardness'. The President also noted '…we had set ourselves a goal of joining the ranks of advanced nations and we can only achieve it by accelerating reforms, by relying on science, education and innovation.'

The President underlined the importance of revising the higher education system, improving materials, disciplines and standards, providing academic and financial independence, increasing the enrolment rates in higher education and encouraging the young population to pursue higher education by providing state grants (with separate grants to be provided for female students).

Digital technologies and digitalization will be promoted in all sectors from 2020. In his address, the President emphasized that 'in order to achieve sustainable development, we must master digital knowledge and information technology, to enable us to take the shortest path to comprehensive progress. In today's world, digital technology plays a crucial role in all areas'.

Four scientific disciplines were selected as the priority areas for 2020: mathematics, chemistry, biology and geology. Each year, attention will be paid to the development of several areas of science.

Source: President Shavkat Mirziyoyev's address to the Oliy Majlis, 24 January 2020.

With the impetus given by the reforms, real GDP increased at an annual rate of 5.1% in 2018, compared with an increase of 4.5% in 2017. The economy continued to grow steadily in the first three quarters of 2019 at 5.7% year on year.[17] However, in spite of the economic growth, the unemployment rate – particularly

16 https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=TJ-UZ-KG-TM-KZ
17 World Bank and EBRD data, 2019 https://data.worldbank.org/country/uzbekistan

youth unemployment – remained high: 10.3% of the total labour force between 15–24 years of age was unemployed in 2019, while the total unemployment rate was 5.5% in the same year.[18] In addition, poverty is still an issue and 11.4% of the population live below the national poverty line.

The gross domestic expenditure on research and development (GERD) as a percentage of GDP is quite low and stood at 0.2% between 2008 and 2017, according to the UNESCO Institute of Statistics (UIS).

The current STI policy of Uzbekistan is defined in the Presidential Decree No. PD-5544 'On Approval of the Strategy for Innovative Development of the Republic of Uzbekistan for 2019–2021', adopted in September 2018.[19] The strategy sets out ambitious goals for the enhancement of STI. The main target is to place the country among the top 50 economies in the Global Innovation Index by 2030. To achieve this, it is aimed to quadruple the GERD from the current 0.2% of GDP to 0.8% of GDP by 2021, improve scientific excellence, and strengthen the links between education, science and industry. Moreover, the government aims to place universities in Uzbekistan among the top 1,000 in the international rankings.

With the new policy, which places innovation at the heart of the development process, the actions to create a robust national innovation system (NIS) have also been initiated. An important step has been the creation of the Ministry of Innovative Development (MoID) in November 2017 to lead the implementation of the strategy, as well as the formation of the Republican Council on Science and Technology in November 2019 as the high-level body for policy formulation and coordination. At the same time, steps have been taken to reinforce the system, such as the enhancement of the infrastructure and improvement of working conditions in the Academy of Sciences, and the advancement of the status of researchers.

There are several direct and indirect policy instruments implemented in the country. Existing policy measures mainly focus on the creation of start-ups, transfer of technology and development of human capital for research. The MoID is managing two funds to support STI: the 'Fund for Supporting Innovative Development and Innovative Ideas' and the 'Presidential Fund for the Commercialisation of the Results of Scientific and Scientific-Technical Activities'. There is also an international internship scheme, launched two years ago for young researchers. Indirect measures include the fiscal incentives offered in technology parks and other innovation infrastructures. Attempts to commercialize research results from research institutes (RIs) have as yet been unsuccessful due to limited capabilities, knowledge and experience in the valuation of intellectual property, and the management of the negotiation process with potential technology buyers.

1.1.2. Methodology

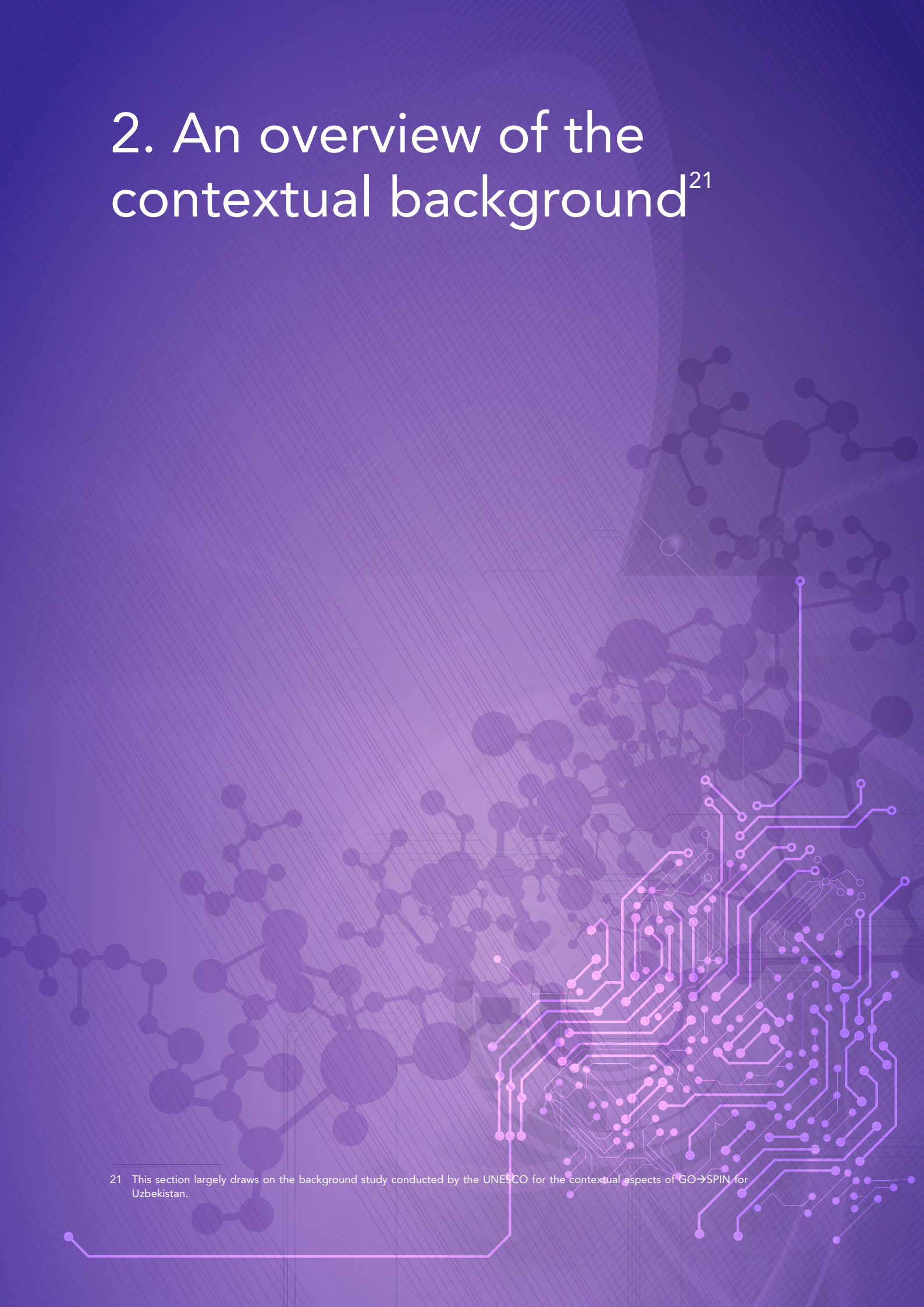
The main tool used in this study is UNESCO's GO→SPIN (Global Observatory of Science, Technology and Innovation Policy Instruments) report methodology. GO→SPIN[20] is used to analyse STI systems in different national contexts. For this purpose, it maps STI landscapes and reviews STI policies and their implementation through stocktaking exercises. Considering the limitations, as well as the fact that the STI system in Uzbekistan is at its nascent stage, a simplified version of the GO→SPIN methodology was used in this study.

In order to prepare this report, a methodology based on primary and secondary research and analysis was used. The primary data and information were collected during a three-day mission organized in Tashkent between 10 and 12 December 2019, where interviews with the key stakeholder organizations of the STI system were conducted. The mission was coordinated with and facilitated by the Ministry of Innovative Development, and a consultation with the first deputy minister took place on the last day of the mission. The secondary data and information sources reviewed include the policy document, reports, databases and legislation published by national authorities and international organizations.

The cut-off date for the data and information used in this report was 27 December 2019.

18 https://data.worldbank.org/indicator/SL.UEM.1524.ZS?locations=UZ
19 https://lex.uz/docs/3913186
20 https://en.unesco.org/go-spin and https://gospin.unesco.org/

2. An overview of the contextual background[21]



21 This section largely draws on the background study conducted by the UNESCO for the contextual aspects of GO→SPIN for Uzbekistan.

Contextual factors determined by historical experiences and conditions, as well as the social and economic situation of a country, play an important role in shaping the national and regional STI ecosystems and the policy framework. This section presents brief background information about these factors in Uzbekistan, drawing on a study previously conducted by UNESCO.

The Republic of Uzbekistan is a landlocked country, which shares borders with Kazakhstan to the north, Kyrgyzstan and Tajikistan to the east and south-east, Turkmenistan to the west and Afghanistan to the south. Its territory is a mixture of mountains and plains (the latter covers 45% of the surface). The climate in the country is continental, with temperatures varying from -6° C in January to about 32° C in June.

Uzbekistan's soil is very rich. About 100 different types of minerals were discovered in the country, among which 60 benefit the national economy. It has the fourth most abundant gold stock in the world and accumulates important reserves of natural gas, gold, copper, bismuth and oil.

With a population of about 32,656,700 inhabitants[22] in 2018, Uzbekistan is the most populated country in Central Asia, representing nearly 46% of the entire population of the region.[23] It has the third largest population among the Commonwealth of Independent States (CIS) after Russia and Ukraine. The median age is 28.6 years and 44.49% of the population is between 25 and 54 years old.[24]

The capital city, Tashkent, is the most populated city in Central Asia, with about 2,393,176 inhabitants in 2016.[25] The other large cities are Samarkand (519,231 inhabitants), Namangan (493,336 inhabitants), Andijan (416,243 inhabitants) and Bukhara (274,721 inhabitants).[26] On the other hand, some 35.1% of the population still live in rural areas.[27] Due to the hot and dry climate, mountains and desert, most of the population is concentrated in oases. The population density is 73 people per km^2, although there are large disparities between regions: the average population density is extremely low in the desert regions Karakalpakstan and Navoi with about 8 people per km^2, whereas it is around 500 people per km^2 in the Ferghana Valley, which is dominated by probably the most agriculturally fertile plains of Central Asia thanks to the Syr Darya river.

2.1. A BRIEF HISTORICAL PERSPECTIVE

Uzbekistan represents one of the first areas of civilization – traces of human presence from hundreds of thousands of years ago have been discovered in the region of Tashkent. Constant invasions and migrations of nomads mark the history of the country. The first people to occupy Central Asia were Iranian nomads during the first millennium BC. In the middle of the sixth century BC, the Persians conquered the region and the cities of Bukhara and Samarkand became political, religious, cultural and administrative hubs. Then, in 334 BC, Alexander the Great began his Asiatic conquest. He won complete control of the region in 328 BC. At that time, the dominant religion was Zoroastrianism but some minorities also practised Buddhism, Manichaeism and Christianity.

The Muslim conquest of the Uzbekistan territory began in the eighth century. Bukhara became the leading place for learning art and culture in the Arab world and even had an astronomical observatory shortly after that time, as well as libraries where intellectuals discussed mathematics, medicine and philosophy. The official language became Arabic and the leaders intensively promoted Islam as it emerged as a new religion. The Muslim influence sharply decreased at the end of the ninth/beginning of the tenth century, since several Turkish nomad groups arrived in the region and promoted the already-known Persian culture. In 1219, the Mongols began their conquest of Central Asia. In the fourteenth century, Timur became the ruler of what is today Uzbekistan and seized all western Central Asia, the Caucasus and the Ottoman Empire. Timur undertook several social developments, such as the patronization of scientists and artists. In 1510, the Uzbeks completed their conquest of Central Asia, including the present-day Uzbekistan.

22 https://data.adb.org/dataset/basic-statistics-asia-and-pacific
23 http://www.uz.undp.org/content/uzbekistan/en/home/countryinfo.html
24 https://www.indexmundi.com/uzbekistan/demographics_profile.html
25 http://data.un.org/Data.aspx?q=uzbekistan+cities&d=POP&f=tableCode%3a240%3bcountryCode%3a860
26 http://worldpopulationreview.com/countries/uzbekistan-population/cities/
27 https://www.worldometers.info/world-population/uzbekistan-population/

The conquest of Central Asia was the main imperial foreign policy goal for the Russian Tsar Alexander I at the beginning of the nineteenth century. After several military conflicts, the entire present-day Uzbekistan had fallen under direct Russian rule or had become a Russian protectorate, depending on the regions. During the Russian Empire period, an Uzbek middle class emerged and the cotton industry sharply increased. The revolutions of February and October 1917 in Russia encouraged the Uzbek nationalists to revolt against Russia's authority. After the collapse of the Russian monarchy, a dual power was established in Tashkent, gathering members of the Russian Soviet provisional government and native Muslim Uzbek people.

In 1924, Uzbekistan became a Soviet Socialist Republic (SSR), first with Tajikistan and then as its own SSR in 1929. With the increased focus of the Soviet decision-makers on education, the literacy rate among the Uzbek population reached 41% by the end of 1941, and the number of researchers exceeded 1,000 by the end of the twentieth century. The Second World War revealed the voluntary and loyal character of Uzbeks towards the Union of Soviet Socialist Republics (USSR) and their homeland. Uzbek industry skyrocketed in order to respond to the demands of the war. Despite the conflicts, the Soviets continued to develop their industry and culture, including science.

In 1943, the Uzbek Science Academy was created and included 22 scientific institutions by the end of 1944. Today, the Academy is still the most important scientific organization of the country (see Section 4). After Stalin's death in 1953, Khrushchev adopted a less totalitarian way of governing. It allowed more Uzbeks to join the communist party and to obtain government positions, which were previously occupied by Russian Soviet elites. In the 1980s, Brezhnev intended to regain control of the region and ordered a massive purge for many people identified as 'political enemies' (mostly nationalist Uzbeks). At the same time, the level of corruption increased among Russian elites, which deepened the Uzbeks' nationalism. In 1991, after a decade of political instability and economic downturn, the USSR collapsed and Uzbekistan gained its independence on 31 August 1991.

In December 1991, the independence referendum was organized, the parliament was elected and Islam Karimov, the former General Secretary of the Uzbek communist party under the Soviet Union, became the new nation's first president. The current constitution was adopted on 8 December 1992, and several amendments were made in 1997, 1999 and 2003. Even though the communist party of Uzbekistan disappeared, the People's Democratic Party of Uzbekistan was its replica, with the same decision-makers as in the Soviet era. The democratic momentum of independence catalysed the consolidation of institutions and the liberalization of the economy.

After independence, the higher education system suffered from an interruption of Soviet funds. The state was unable to provide the laboratories, libraries, computers or publishing facilities needed to efficiently develop higher education and research centres. However, in 2012, to boost research and development (R&D), the government elaborated a plan towards 2020 and defined eight R&D priorities[28] to be pursued until 2020, based on the needs of industry:

a. Constructing an innovative economy by strengthening the rule of law
b. Energy and resource savings
c. Developing renewable energy use
d. Information and communication technologies
e. Agriculture, biotechnology, ecology and environmental protection
f. Medicine and pharmacology
g. Chemical technologies and nanotechnologies
h. Earth sciences, with a focus on geology, geophysics, seismology and raw mineral processing

After the death of President Karimov in September 2016, Shavkat Mirziyoyev, who served as the prime minister between 2003 and 2016, won the presidential election, with 88.6% of the votes. Since his election, President Mirziyoyev has instigated multiple reforms, especially in relation to economic liberalization and STI development. In January 2019, the government adopted a vision plan for 2019–2021 called the 'Reform Roadmap', setting up the medium-term social and economic goals, including macroeconomic

28 UNESCO, 2015.

stabilization, economic liberalization, social protection and sustainable development.[29] The president also encourages Uzbekistan's regional and international integration. The country already belongs to several organizations, such as the Organization for Security and Co-operation in Europe (OSCE), the Economic Cooperation Organization (ECO), the Shanghai Cooperation Organization (SCO) and the Central Asia Regional Economic Cooperation (CAREC).

2.2. HISTORY OF DEVELOPMENT OF UZBEK SCIENCE

The development of science and culture in the territory of Uzbekistan began in ancient times with the progress over centuries in certain disciplines such as astronomy, mathematics, medicine, chemistry, history, philosophy, linguistics, literature, and arts and crafts (sculpture, weaving, pottery, glass making, etc.). Nowadays, Uzbek scientists are actively exploring the scientific heritage of ancient scholars; enriching science with new discoveries and making a significant contribution to world science.

Between the ninth and tenth centuries, Central Asia became one of the largest scientific and cultural centres of the East, where the first scientific research institutions were established and scientific communities were formed. In the eleventh century, Urgench, the capital of Khorezm, was a cultural hub of the region. The ruler Horezmshah Abul Abbas ibn Ma'mun, having a keen interest in culture and science, supported scientists, poets, musicians, calligraphers, architects and artists. The palace court of Khorezm in Urgench included such great thinkers of the East as the encyclopaedists: physician Ibn Sina (Avicenna) and the representative of the exact sciences Abu Rayhan Biruni, historian Ibn Miskawayh, mathematician Abu Nasr ibn Iraq, philosopher Abu Sahl Masihi and physician Ibn Hammar, among others.

The first scientific academy in the Muslim East, named 'Baytan-Hikama', or 'Bayt al-Hikma', was headed by a distinguished mathematician Al-Khwarizmi (783–850), who contributed to measurements to determine the length of a degree of a terrestrial meridian. His works included the construction of an astrolabe, the scientific works 'Kitab al-Jabr wa-l-Muqabala' ('The Compendious Book on Calculation by Completion and Balancing') and one of the world's first sets of 'Astronomical Tables', as well as a number of scientific treatises, such as the 'Treatise Concerning the Hindu Art of Reckoning', 'Treatise on the Sun-Dial' and 'Treatise on Music', among others. Al-Khwarizmi was the first to have solved a series of algebraic equations, the first to introduce into the new series of numbers a 'zero' mark, which expanded the theory of numbers and provided an opportunity to create negative numbers. Due to Al-Khwarizmi's achievements, a new branch of mathematics called 'algebra' was named in his honour. In his famous work 'Kitab al-Jabr wa-l-Muqabala', algebra was regarded for the first time as an independent branch of mathematics. 'Algorithm', the fundamental concept of modern cybernetics, is etymologically connected with the name Al-Khwarizmi.

Urgench was also home to the 'House of Proficient Experts', which can be considered as the 'Academy' – a place where scholars carried out research in the field of astronomy, philosophy, mathematics and medicine. Thus, in the East, particularly in Central Asia, the organization of scientific activity in the form of an academy had become a tradition.

In Samarkand, the academy was organized by Mirzo Muhammad Taragai Ulughbeg in the fifteenth century. It consisted of an observatory, a plentiful library and a higher educational institution, which was called the 'madrasah'. In the madrasah, along with religious sciences, other disciplines, such as mathematics, geometry, astronomy, medicine and geography, were also taught. Several renowned scientists like Qazizadeh Rumi Giyasiddin Jamshid al-Kashi and Ali Kushchi worked in the Ulughbeg Academy, and the scope of the research was highly differentiated. The Ulughbeg Academy in Samarkand has made a significant contribution to the development of sciences such as mathematics, astronomy and geography.

The period between the ninth and fifteenth centuries saw a rapid development of exact and natural sciences like mathematics, astronomy, geodesy, mineralogy, medicine and pharmacology. The level of research pursued by the scientists Muhammad al-Khwarizmi, Ahmad al-Fergani, Abu Nasr Farabi, Abu

29 World Bank, 2019

Rayhan Beruni, Mahmud of Kashgar, Abu Ali Ibn Sina (Avicenna), Nasriddin Tusi, Qazi-zadeh Rumi, Jamshid Kashi, Ulughbeg, Ali Kushchi and others was in some areas much higher than the work conducted in more recent times by thinkers in other countries. Abu Rayhan Beruni wrote books on history, chronology, pharmacognosy, mineralogy, astronomy, mathematics, and laid the theoretical basis and calculated the availability of a new continent on the Earth. He also solved a number of other problems that have received worldwide recognition. Upon Abu Rayhan Biruni's arrival in the region, many researchers joined him to form the Academy of Mamun in Kunya-Urgench (now Khiva) and he worked there for a long time.

In the same period, the same place hosted another great Central Asian scholar: Abu Ali Ibn Sina (Avicenna), who was a truly encyclopaedic scholar working as a naturalist, philosopher, physician, astronomer, mathematician, musician, writer and poet. The phrase *Madadi Sino* which characterizes the work of Ibn Sina was introduced and adapted to European languages as a trend in science: 'medicine'. A renowned scholar of the eighteenth-century, naturalist Carl Linnaeus, praised the achievements of Ibn Sina in botany and gave his name to a rare evergreen plant species. Ibn Sina wrote over 400 works, 240 of which have survived. The Institute of Oriental Studies named after Abu Rayhan Beruni of the Uzbek Academy of Sciences contains over 50 of his works and a number of commentaries on them. Among these works are the five-volume *Al-Qanun-fi l-Tibb* (*The Canon of Medicine*), which is the crown of his creative activities and scholarly writings. This work had raised medical science to a very high level at that time, and hundreds of years after his death, it was widely recognized in Western Europe. In the twelfth century, *The Canon of Medicine* was translated into Latin and circulated in manuscript format. In 1493, it was published in Latin in Venice, and within a century reprinted 16 times. Medical science was taught on the basis of this work in all reputable educational institutions in Asia and Europe for 500 years. This invaluable work has not lost its scientific significance even today.

Another scientist, the mathematician and astronomer, Qazi Zadeh Rumi (Salahiddin Musa ibn Muhammad ibn Mahmud), was a mentor of Ulughbeg. He made a significant contribution to the creation of the school of Ulughbeg. For his achievements in science, Rumi was called *Aflotuni Zamon* ('Plato of his time'). An outstanding mathematician and astronomer, Al-Kashi (Giyasiddin Jamshid Kashi) first introduced the decimal numbers on the positioning basis in mathematics and accurately calculated the values of sin 1° and of the π (pi) character up to the 17th number sign in the decimal system. A number of his outstanding works are in the field of astronomy. Together with Qazi Zadeh Rumi, Al-Kashi supervised the construction of the observatory of Ulughbeg.

Muhammad Taragai Ulughbeg also left behind a great scientific and cultural heritage, *Zij-i jadidi Guragoniy* (*New Guragan's Astronomical Tables*) – the world-famous work 'Ulughbeg's Zij' of a great scientist. Ulughbeg built an observatory and madrasah in Samarkand and established his own academy. Together with his students, he studied and made a list of more than a thousand stars (a 'star map'). In the Academy of Ulughbeg, scientists conducted research not only in astronomy but also in mathematics, philosophy, history and other sciences. The famous astronomer Ali Kushchi (Mawlana Alauddin Ali bin Mohammed Kushchi) who worked at the Academy of Ulughbeg wrote world-famous scientific works on mathematics and astronomy. He believed that the change of seasons was the result of the approximation of the Earth to the Sun and the corresponding effects of sunlight on the surface temperature of the Earth, and from a scientific point of view, he correctly identified the process of the eclipse of the Sun. Ali Kushchi's works greatly influenced the development of astronomical and mathematical science in the sixteenth and seventeenth centuries.

Mirzo Ulughbeg, Al-Kashi, and Ali Kushchi made a significant contribution to the theory of numbers and raised the level of the knowledge on observational astronomy. In 1428–29, a unique astronomical observatory was built with the main instrument, a quadrant with a radius of 40 m that was unmatched in size. A unique catalogue of 1,018 stars, compiled in Samarkand on the basis of 30 years of observations, remained the best in the world for many years. The achievements of Ulughbeg's astronomical school had a great influence on the development of science in the West and East. His scholarly works were translated into many languages and were widely used in Europe and the USA. The name of Mirzo Ulughbeg in the history of world science stands alongside those of Tycho Brahe, Johannes Kepler, Copernicus and Galileo Galilei. A portrait of Mirzo Ulughbeg takes a worthy place in the Great Hall of Moscow State University in the

memorable historical gallery of the greatest scientists of all time. Sculptural monuments to Mirzo Ulughbeg were established in several cities of Uzbekistan and in Belgium; the ancient Samarkand observatory is named after him, as well as several universities, including the National University of Uzbekistan, schools, urban areas and the residential settlement of nuclear physicists in Uzbekistan.

The Tashkent Physical and Astronomical Observatory, the first scientific institution in Uzbekistan in the nineteenth century (known today as the Astronomical Institute of the Academy of Sciences) was established in 1873. Initially, the observatory was engaged in organizing expeditions, which resulted in the exact coordinates being determined for over 1,000 locations in the region, and it was only in the 1930s that the observatory began to tackle research problems of fundamental astronomy.

In 1918, special institutions for the training of personnel to be engaged in various sectors of the economy and culture were opened in Turkestan. One of them is the Turkestan People's University, opened on 21 April 1918. Its branches were opened a little later in Andizhan, Kokand, Samarkand, Ferghana, Dzhizak and other cities. In 1919, the Research Institute of Physical Therapy was established in Tashkent. In 1920, the Turkestan State University was established – from 1923, it was known as the Central Asian State University, and in 1960 renamed as Tashkent State University. Today it is called the National University of Uzbekistan. In the 1920s, a number of research institutes in the field of history, medicine, science, etc. were also opened. Subsequently, in order to study and use natural resources in the region, several higher education institutions and a number of research establishments in various fields of science were created in Uzbekistan based on the National University of Uzbekistan.

In 1940, further to the Scientific Committee formed in Tashkent in 1932, a branch of the USSR Academy of Sciences was established in Uzbekistan; this branch has now become the main research centre in the country. At that time, it consisted of the institutes of geology, botany, chemistry and water resources (from 1941, the Institute of Energy Industry and Power Engineering); history, language and literature; soil science sector, zoology, physics and mathematics (together with helio-technological laboratory); Tashkent Astronomical Observatory (together with the Kitab Latitudinal Station); and the Bureau of Economic Research and Cartography. In 1940, the scientific and teaching staff in the research institutes and higher education institutes of Uzbekistan numbered over 3,000 people. During the Great Patriotic War (1941–1945) in the country, there were more than 40 research institutes and higher education establishments.

The Branch of the USSR Academy of Sciences in Uzbekistan was reorganized into the Academy of Sciences of the Uzbek Soviet Socialist Republic (UzSSR) in 1943, and created the research Institutes of Physics and Technology, History, Oriental Studies and Economics. The members of the academy included 11 academicians-founders, 18 corresponding members and 3 honorary members. In the institutions of the academy, there were 210 scientific staff members, including 28 doctors and 80 candidates of sciences. In the second half of the 1940s, scientists mainly focused their efforts on the development of the post-war economy, culture, medicine and other industries.

In the 1960s–70s, all the activities of scientific institutions operating in natural and social sciences were completely focused on the priorities of the economic and cultural development of the country. Particular attention was paid to the development of comprehensive research in the field of cotton growing, irrigation, the power generation sector, ferrous metallurgy and other industries. In 1987, the construction of a unique scientific and experimental facility, a 'big solar furnace' which is a bimirror optical helio-energy system, was put into service in the Parkent district of Tashkent.

The Decree of the President of the Republic of Uzbekistan Islam Karimov, dated 8 July 1992 and the Resolution of the Cabinet of Ministers 'On measures of state support for science and innovation', adopted within the frame of implementation of that decree, made significant contributions to the further development of science in the country.

Between 20 September and 12 October 2006, the Academy of Sciences, together with the Ministry of Foreign Affairs and the National Commission of the Republic of Uzbekistan for UNESCO, organized an exhibition and held a scientific conference at the UNESCO headquarters in Paris, dedicated to the 1,000th anniversary of the Khorezm Mamun Academy. Several foreign embassies in Uzbekistan, with the

participation of scientists from the Academy of Sciences, arranged celebration events in honour of the Khorezm Mamun Academy, and conferences were also held by the Research Centre of Faisal Shah of Saudi Arabia, in conjunction with the Kyunghee University of Korea.

The Academy of Sciences focuses attention on fundamental, applied and innovative research studies pursued by research institutions in terms of the transition to a market economy. New ways are currently being developed and implemented to use practically important scientific results, and to encourage the widespread introduction of high technology products and services of research institutions. The Academy of Sciences constantly strives to improve the mechanisms of its activities.

2.3. HUMAN DEVELOPMENT

The Human Development Index (HDI) analyses countries' social development on the basis of three variables: life expectancy, education and living standards. Even though Uzbekistan's HDI is still below the average of the high human development group (0.757), as well as the average of the European and Central Asian countries (0.771), it has increased from 0.595 to 0.710, equivalent to a rise of 19.3%, between 2000 and 2017[30] (Figure 1). During this period, life expectancy at birth increased by 4.9 years, years of schooling rose by 2.4 years and expected years of schooling increased by 0.7.

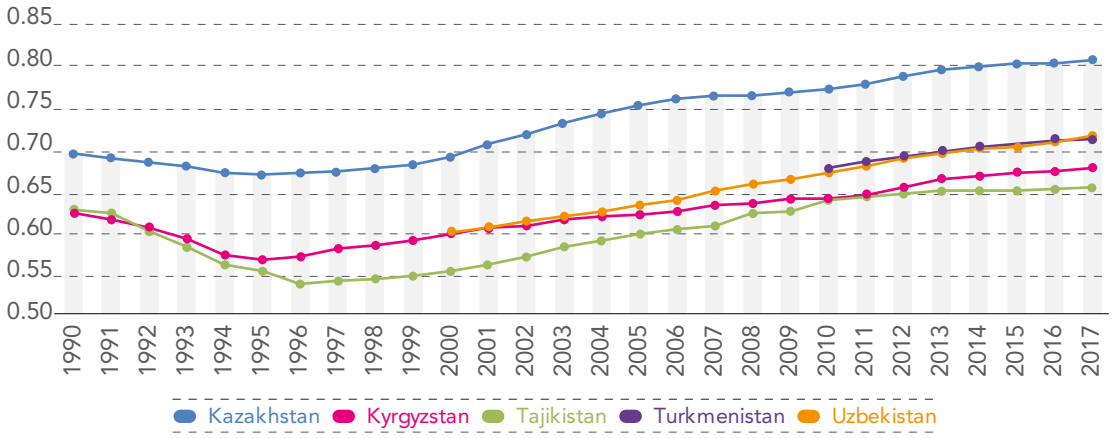


Figure 1. Human Development Index, Central Asia countries (2017)
Source: UNDP[31]

With regard to living standards, 11.4% of the population still live below the national poverty line, 75% of whom reside in rural areas. Nearly 28% of the employed population earn less than USD 1.90 (PPP) per day.[32] The unemployment rate (above 5% of the population) and the low wages result in labour migration to Russia and Kazakhstan.[33]

The Gender Development Index (GDI)[34] for Uzbekistan was 0.945 in 2017 – lower than the average of the European and Central Asian states (0.956) and the high HDI countries (0.957).[35] The Gender Inequality Index (GII)[36] was 0.274 in the same year, ranking the country 59th out of 160 countries, far ahead of Tajikistan and Kyrgyzstan, which ranked 69th and 91st, respectively.[37] The gross national income (GNI) is unequal between genders (4,687 for female and 8,264 for male).

30 http://hdr.undp.org/en/countries/profiles/UZB - Human Development Indices and Indicators: 2018 Statistical Update
31 http://hdr.undp.org/en/data#
32 https://data.adb.org/dataset/basic-statistics-asia-and-pacific
33 http://www.uz.undp.org/content/uzbekistan/en/home/countryinfo.html
34 GDI is a sex-disaggregated measure of the HDI that considers the differences between genders regarding health, education and economic resources.
35 http://hdr.undp.org/en/countries/profiles/UZB - Human Development Indices and Indicators: 2018 Statistical Update
36 Measures gender inequality in reproductive health, empowerment and economic activity.
37 http://hdr.undp.org/en/countries/profiles/UZB - Human Development Indices and Indicators: 2018 Statistical Update

2.4. LONG-TERM ECONOMIC GROWTH AND REFORMS

At the time of the Soviet era, Uzbekistan was one of the least developed SSRs. Heavy industry represented the largest part of GDP, mainly because of natural gas and oil extraction, oil refining, mining and mineral processing. Light industry was also developed and represented about 27.1% of GDP in 1989, thanks to the processing of cotton, wool and silk. Uzbekistan's economic system was highly integrated with the Soviet economy and for this reason it struggled to free itself after independence. Even though several reforms were undertaken in 1992 to liberalize the market and to privatize small shops and residential housing, the government adopted a gradual approach of economic reforms and remained in control of basic consumer goods and energy prices. During the early period of transition, no laws regarding bankruptcy, collateral or contracts were enforced[38] and the economy was based on sectors such as energy, mining, agriculture (cotton, wheat), industry (chemical, automotive, pharmaceutical) and services.

In the 2000s, Uzbekistan's GDP reached an average of 7% (Figure 2).[39] During that decade, the government began to promote actively the privatization of major national enterprises.[40] Government resolutions for a privatization programme were passed in 2005, 2006 and 2007. Uzbekistan did not suffer extensively from the global economic crisis in 2008–2009, as the government injected money into the key sectors of the economy. Moreover, it encouraged the establishment of free economic zones (FEZs) to boost the main sectors of the economy. In December 2008, the FEZ was created in the province of Navoi, followed by two others in Angren (2012) and Dijzak (2013).

In the 2010s, the government started to put emphasis on innovation and entrepreneurship as the key tools to solve socio-economic issues, as well as to boost economic productivity. Thus, in 2012, the Committee for the Coordination of Science and Technology Development formulated the R&D priorities for the country, including the development of an innovative economy.[41] In 2017, the government also created the Ministry of Innovative Development[42] (see Section 4).

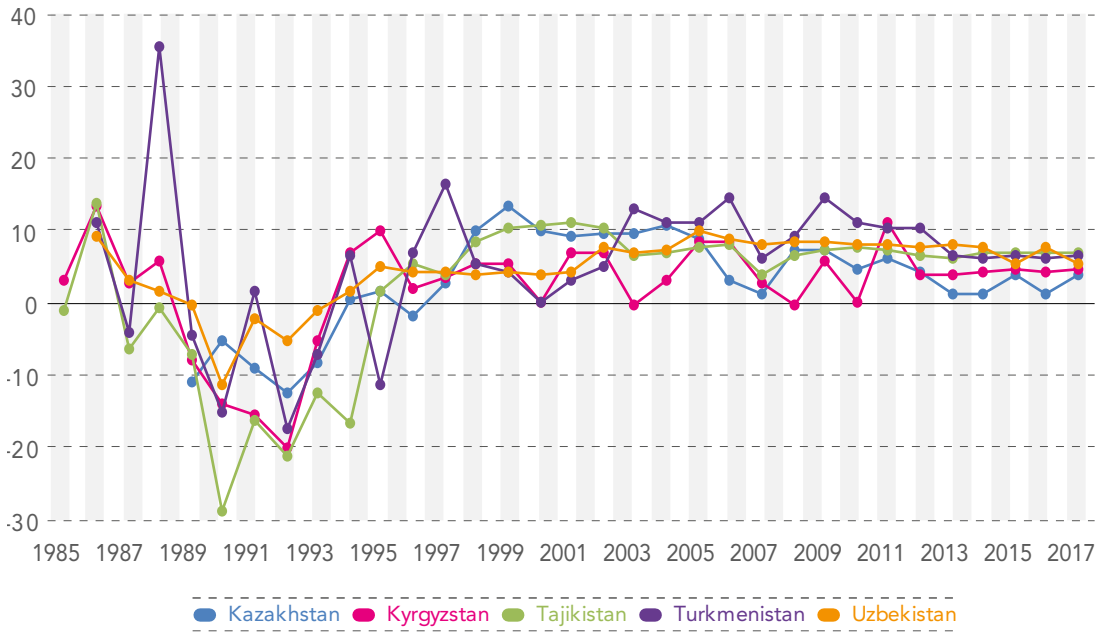


Figure 2. GDP growth, Central Asia countries (annual %)
Source: UIS.

38 http://countrystudies.us/uzbekistan/8.htm
39 UNESCO, 2015
40 http://www.europarl.europa.eu/RegData/etudes/briefing_note/join/2013/491518/EXPO-INTA_SP(2013)491518_EN.pdf
41 UNESCO, 2015
42 https://www.un.int/uzbekistan/news/practical-measures-taken-government-uzbekistan-implement-2030-agenda-sustainable-development

In 2018, the average annual inflation rate was high (17.9%), import spending sharply increased (by 28.8% in a year) and most exports declined (except gas and metal exports, which grew by 65.8% and 27.6%, respectively). The value-added added growth rate was equivalent to 0.2% for the agriculture sector, 10.5% for industry and 5.4% for services.[43]

Between 1990 and 2017, the GNI per capita increased by 233.5%[44] and economic growth accelerated (the annual growth rate increased from 4.5% in 2017 to 5.1% in 2018),[45] reflecting the high level of development in industry and construction. According to the World Bank, even though most of the current economic indicators predict an economic slowdown, one should be optimistic about the future growth of Uzbekistan, which is estimated to equal around 5.3% in 2019 and 6% in 2021.

President Mirziyoyev has determined to reform the country both socially and economically.[46] To this end, the government's 'Action Strategy in Five Priority Areas for the Development of Uzbekistan, 2017–2021' was launched in 2017, which reinforces reforms in the following areas:

- Economic liberalization, including promoting the development of private entrepreneurship and small businesses; improving the investment climate and attracting foreign investment; enhancing efficiency of the banking sector; restructuring the agricultural sector; investment in modern technology.
- Development of the social and environmental spheres, with a focus on *inter alia* creating jobs for young people and in regions; enhancing the role of women, including promotion of entrepreneurship; increasing energy efficiency, including by energy-saving technology and renewable energy sources.
- Improving the legal framework for foreign economic activity and improving relations with neighbours.
- Ensuring the independence of the judiciary and protection of civil and property rights; strengthening the legal system and fighting corruption.
- Reform of public administration through training, decentralization and e-governance; increasing transparency and public accountability; strengthening the role of parliament, political parties and civil society, among other things.

Moreover, the government adopted a 'Reform Roadmap 2019–2021', identifying the short-term economic reform priorities. The five key objectives of the reform were determined in order to (a) maintain macroeconomic stability, (b) accelerate the market transition, (c) strengthen social protection and citizen services, (d) strengthen government's role in a market economy, and (e) preserve environmental sustainability. Aligned with these objectives, and in order that Uzbekistan become an attractive trading partner and centre, the government began to implement policies for liberalizing the currency, lifting trade and investment barriers, reducing business regulations and opening the market to attract investments and to boost imports and exports.[47]

Since then, major steps have been taken to implement the reforms, such as the approval of the anti-corruption law, creation of new FEZs, reduction of the state's influence in non-strategic companies and creation of one-stop shops for the business sector.

The reforms led to an improvement in Uzbekistan's position in the World Bank's Doing Business ranking: the country is listed among the 20 economies where business climates improved the most, and ranked 69th globally in 2020, having moved up from 76th place in 2018.[48]

43 https://data.adb.org/dataset/basic-statistics-asia-and-pacific
44 http://hdr.undp.org/en/countries/profiles/UZB - Human Development Indices and Indicators: 2018 Statistical Update
45 https://data.adb.org/dataset/basic-statistics-asia-and-pacific
46 World Bank, Uzbekistan Institutional Capacity Building Technical Assistance Project (P168180)
47 https://www.worldbank.org/en/news/press-release/2018/06/26/uzbekistans-goal-to-transform-economy-boost-growth-and-create-jobs-gets-world-bank-support-with-us-500-million-loan
48 https://openknowledge.worldbank.org/handle/10986/32436

2.5. CHALLENGES FOR THE SDGS

Uzbekistan endorsed the Sustainable Development Goals (SDGs) in 2015. Sixteen national SDGs with 127 related targets were adopted with the Government Resolution No. 841 'On Measures to Implement the National SDG Goals and Targets until 2030' in October 2018. The Coordination Council, along with a roadmap for implementing and monitoring the SDGs, have also been established, and a web portal of the State Statistics Committee was created to report on the progress of localization and achievement of the SDGs.[49]

A brief assessment of the progress regarding the SDGs that concern the STI context is given below:

- Quality education: Since 2000, Uzbekistan has made great progress and reached the universal primary education target. In 2017, as part of the Education Sector Plan (ESP) covering the 2013–2017 period, 12 schools were established and 320 were refurbished. Moreover, special schools that focus on exact sciences were formed. Systemic and infrastructure improvements were made to the Academy of Sciences, in order to enable Uzbekistan to become a dynamic actor in the fields of scientific research, innovation and advanced technologies.[50] Currently, the second ESP covering the period 2019–2023 is being implemented.[51]
- Gender equality: In Uzbekistan, the school life expectancy (primary to tertiary) of women is nearly equal to that of men (11.82 years versus 12.2 years).[52] Similarly, the literacy rate of women above 15 years old has reached 99.98%, which is similar to that of men (99.99%). However, only 36% of women are enrolled in a higher education degree.[53] Regarding the female labour force, Uzbekistan has the second highest rate of female participation in Central Asia (with a female-to-male labour force participation rate of 68.5% in 2018). The government is committed to increase women's participation in public and political life to achieve the SDGs. As a result of recent efforts, 25% of parliamentary seats are held by women and the share of women senators is 32%. However, women are under-represented in the private sector (only 36% and 25% of the full-time workers of medium and large enterprises, respectively, are women)[54] Since 2017, the Women's Committee of Uzbekistan and UNDP have collaborated to boost women's participation in public administration and economic life. This project also includes training programmes and seminars for girls and women in mathematics, physics, programming, engineering, chemistry, biology and other natural sciences.[55]
- Clean water: Access to drinking water remains one of the greatest challenges for Uzbekistan. Only 51.2% of the population uses safely managed water sources and the inequality between regions is alarming: the share of population using safely managed water sources in urban and rural areas is 86.5% and 31.1%, respectively. The Ministry of Finance intends to develop the isolated and neglected Aral Sea region (especially the Republic of Karakalpakstan and the Province of Khorezm), investing around USD 25 million in order to ensure access to drinking water and improve living conditions.
- Clean energy: The government recognizes that there is a need to improve its environmental management. In 2016, renewable energy represented only 3.2% of total energy consumption and no electricity power from renewable energy sources (excluding hydroelectric) was produced. Between 1990 and 2013, the fossil fuel energy consumption of Uzbekistan slightly decreased from 99.1% to 97.7% of its total energy consumption. During this period, the percentage of alternative and nuclear energy and that of combustible renewables and waste slightly increased from 0.9% to 1.9% and from 0.007% to 0.009%, respectively. In 2015, electricity production from oil, gas and coal sources represented 79.4% of total electricity production. In the same year, 20.7% of electricity production came from hydropower resources.

49 http://nsdg.stat.uz/
50 https://www.un.int/uzbekistan/news/practical-measures-taken-government-uzbekistan-implement-2030-agenda-sustainable-development
51 https://www.globalpartnership.org/sites/default/files/2019-04-gpe-esp-uzbekistan.pdf
52 UIS, 2017
53 http://www.uz.undp.org/content/uzbekistan/en/home/countryinfo.html
54 ADB, 2019
55 http://www.uz.undp.org/content/uzbekistan/en/home/presscenter/pressreleases/2017/11/20/wc-undp-will-promote-women-empowerment.html

- According to World Bank data, with its carbon dioxide emissions of 105,213.6 kilotons in 2014, Uzbekistan was one of the biggest polluters in Central Asia along with Kazakhstan and Turkmenistan (in the same year, Kazakhstan and Turkmenistan produced 248,314.6 kilotons and 68,422.6 kilotons of carbon dioxide, respectively). In 2017 a Presidential Resolution was issued to develop renewable energy sources from the private sector and introduced temporary tax incentives for the sector. The resolution included a list of projects for each technology, including new hydro, solar and onshore wind energy.[56]
- Decent work and economic growth: Working conditions in Uzbekistan remain one of the main social and economic challenges. Since 2018, President Mirziyoyev has taken measures to eradicate child labour as well as forced labour, an issue that concerns the cotton industry in particular during the harvest season (it is the world's largest recruitment operation, with about 2.6 million seasonal workers per annum). A number of structural changes and reforms to recruitment practices have been implemented so far. The International Labour Organisation (ILO) supported these initiatives and acknowledged that the measures were effective. Moreover, the government increased wages and improved rates of pay so that workers are paid more at the end of the season, when the conditions are less favourable and there is less cotton to pick.[57] In recent years, the Uzbek government, supported by international organizations, has undertaken 17 development projects totalling USD 2.8 billion. All these projects aim to support economic growth and improve living standards. For example, the establishment of new industrial enterprises created around 336,000 jobs in 2017.[58]
- Data, monitoring and accountability: Uzbekistan does not have recent census data, which makes it difficult to analyse the country's development and to implement socio-economic reforms efficiently. The last population census was held in 1989. In February 2019, President Mirziyoyev endorsed a decree to conduct a population census in 2022. The United Nations Population Fund (UNFPA) supports this initiative, as population-related elements are present in about 40% of the SDG indictors.[59]

56 http://global-climatescope.org/policies/5425
57 https://www.ilo.org/global/about-the-ilo/newsroom/news/WCMS_650697/lang--en/index.htm
58 https://www.un.int/uzbekistan/news/practical-measures-taken-government-uzbekistan-implement-2030-agenda-sustainable-development
59 https://uzbekistan.unfpa.org/en/news/uzbekistan-will-have-population-census-2022

3. STI performance and policy framework

This section provides an overview of the STI performance of Uzbekistan, as well as recent developments in the national innovation system (NIS), STI policies, legislation and policy instruments.

3.1. STI PERFORMANCE

A snapshot of the STI performance of Uzbekistan is given below using the basic STI statistics for the country.

3.1.1. R&D expenditures

Expenditure and human capital for R&D are the main indicators for STI inputs for a country. According to the UIS, R&D expenditure in Uzbekistan, expressed as the gross domestic expenditure on R&D (GERD), has remained at 0.2% since 2008 (Figure 3). Between 2012 and 2017, the intramural R&D expenditure from higher education and business enterprise sectors increased from 13.95% to 19.15%, and from 26.95% to 38.26% respectively (Figure 4). While the majority of R&D expenditure came from the government in the same period, it sharply decreased from 58.61% in 2012 to 41.23% in 2017. A modest but rising share of R&D expenditure also came from the private non-profit organization sector (from 0.49% in 2012 to 1.36% in 2017).

Figure 3. R&D expenditure in Uzbekistan (2008–2017)

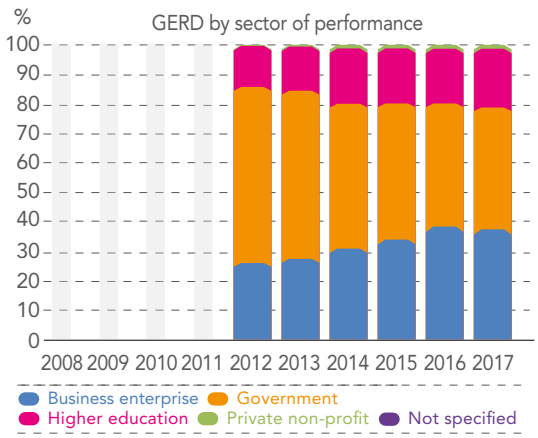


Figure 4. R&D by performance sector (2008–2017)

Source: UIS, http://uis.unesco.org/en/country/uz?theme=science-technology-and-innovation

During the period 2008–2017, the main sources of R&D funding have been the government and business enterprises. The share of government funding rose from 45.54% in 2008 to 56.94% in 2017. In the same period, the share from business enterprises decreased from 49.92% to 41.23% of the total amount of R&D funding. The share of funds from the higher education sector and other sectors remained negligible (Figure 5).

Between 2014 and 2017, around two-thirds of R&D funding was allocated to engineering and technology, and natural sciences. The remaining funds were divided between humanities, social sciences, agricultural sciences and medical sciences. The R&D funding allocated to natural sciences increased from 31.12% of the total available funding in 2014 to 37.04% in 2017. In same period, R&D funding for agricultural sciences research also rose from 7.49% to 9.67%. On the other hand, the funds for engineering and technology decreased from 36.23% in 2014 to 30.62% in 2017. The funding for R&D activities in medical sciences, social sciences and humanities also declined from 7.38% to 6.46%, from 11.04% to 10.58% and from 6.73% to 5.62%, respectively, during these four years.

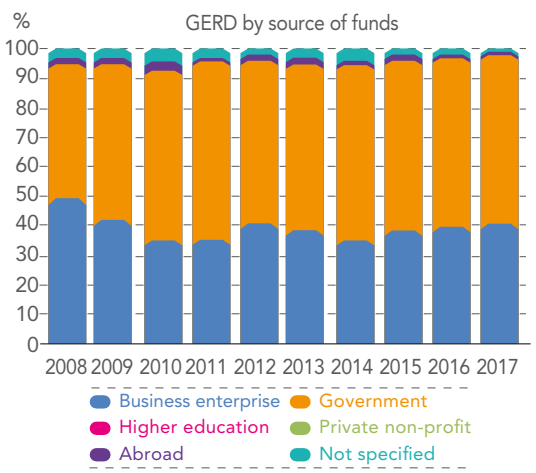


Figure 5. GERD by source of funds (2008–2017)

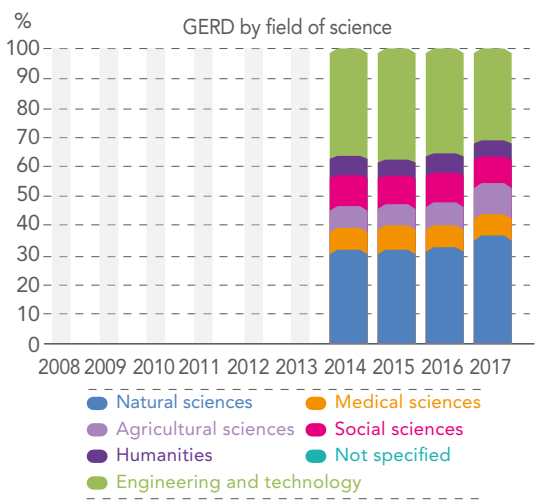


Figure 6. GERD by field of science (2014–2017)

Source: UIS, http://uis.unesco.org/en/country/uz?theme=science-technology-and-innovation

3.1.2. R&D human capital

In Uzbekistan, the number of researchers (both full-time equivalents (FTE) and headcount) has slightly changed between 2008 and 2017. The number of researchers (headcount) was 998.41 per million inhabitants in 2017, and the number of researchers (FTE) was 496.34 per million inhabitants in the same year (Figure 7). The gap between the number of FTE and headcount researchers widened between 2008 and 2017. Female researchers as a share of total researchers remained fairly constant between 2008 and 2017 (both FTE and headcount) at around 40% (Figure 8).

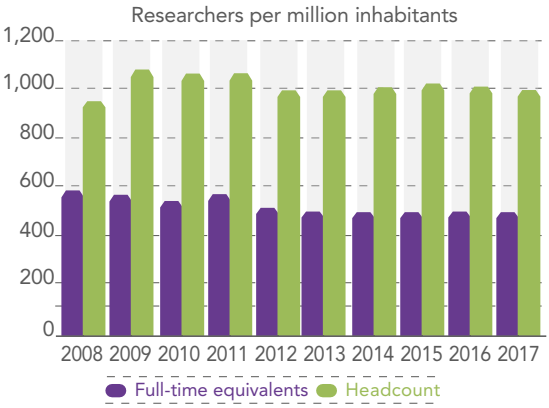


Figure 7. Researchers per million inhabitants (2008–2017)

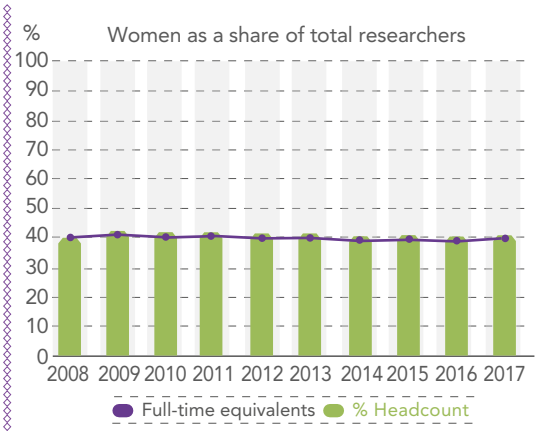


Figure 8. Women as a share of total researchers (2008–2017)

Source: UIS, http://uis.unesco.org/en/country/uz?theme=science-technology-and-innovation

According to UIS data, the majority of researchers were employed in the higher education sector. The share of FTE researchers in the sector grew from 54.01% in 2011 to 59.79% in 2017. There was also an increase in the share of researchers employed by the business enterprise sector in the same period from 12.85% in 2011 to 13.15% in 2017 (Figure 9), while the share of those employed by the government gradually decreased from 32.78% in 2011 to 26.34% in 2017. There was no notable change in the share of researchers in different sector headcounts between 2011 and 2017 (Figure 10). The share of those employed in the higher education sector and the government was 80% and 13.10%, respectively, in 2017. The proportion of researchers employed by the business enterprise sector remained low at 6.53% in the same year.

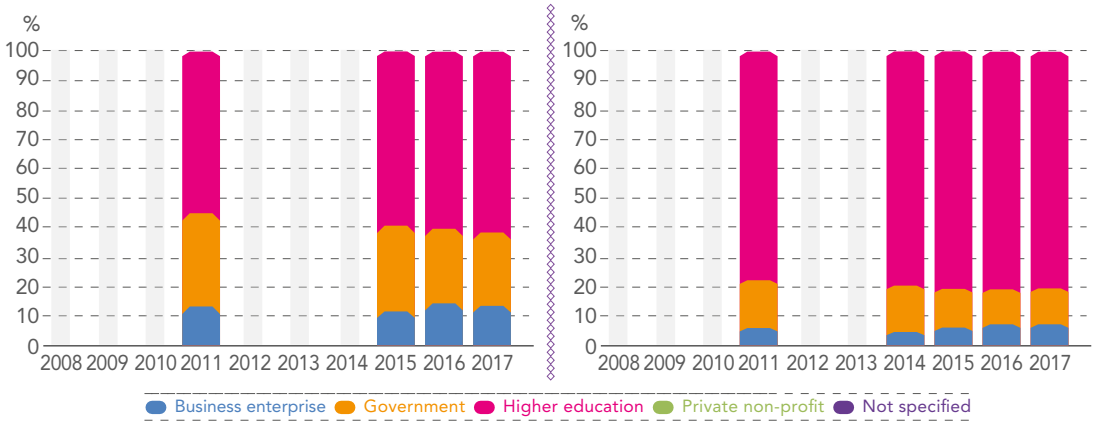


Figure 9. Researchers by sector of employment (FTE)

Figure 10. Researchers by sector of employment (headcount)

Source: UIS, http://uis.unesco.org/en/country/mz?theme=science-technology-and-innovation

3.1.3. Patents and publications

Statistics on intellectual property (IP) and scientific publications provide an indication of the STI outputs of a country. According to the World Intellectual Property Organisation's (WIPO) data, IP filings have increased in Uzbekistan since 2009. The number of patents filed rose from 239 in 2009 to 480 in 2018; that of trademarks increased from 3,291 to 7,993 and industrial design filings increased from 56 to 309 in the same period.

A closer look at the patent data indicates that resident patent applications rose from 238 to 470 between 2009 and 2018, while non-resident applications changed slightly from 174 to 180 in the same period (Figure 11).

Changes in patent grants have not been remarkable: the number of resident patent grants rose from 129 in 2009 to 149 in 2018, whereas that of non-residents fell from 106 to 70 in the same period (Figure 12).

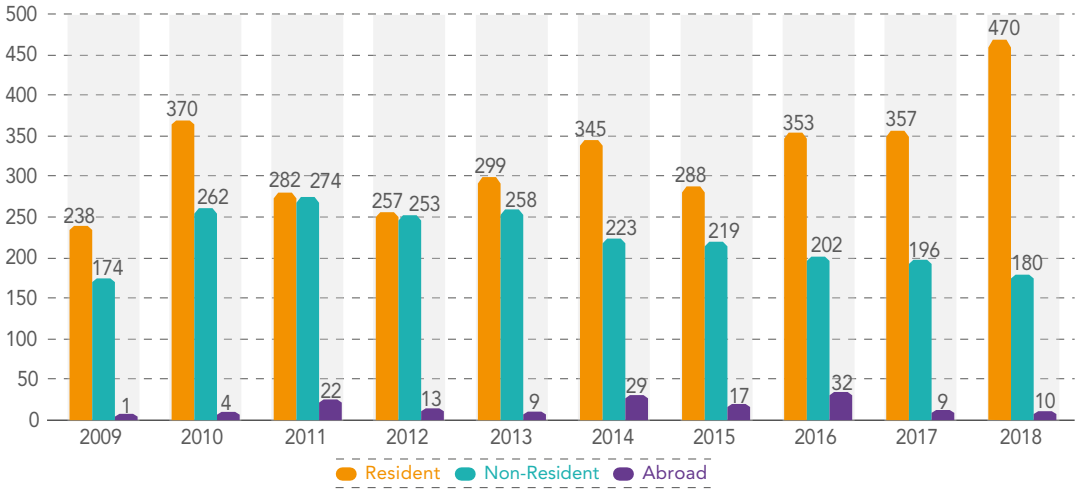


Figure 11. Patent applications in Uzbekistan (2009–2018)
Source: WIPO, https://www.wipo.int/ipstats/en/statistics/country_profile/profile.jsp?code=UZ

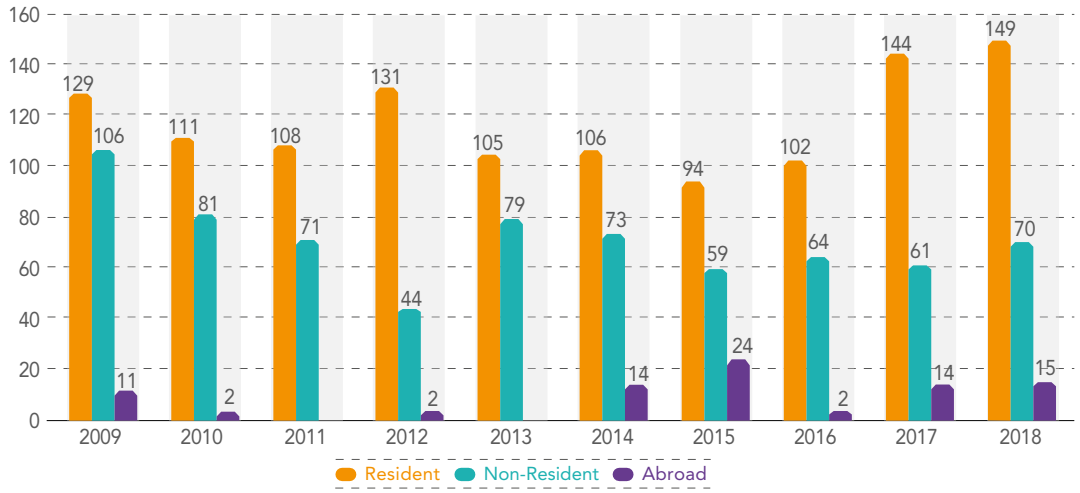


Figure 12. Patent grants in Uzbekistan (2009–2018)
Source: WIPO, https://www.wipo.int/ipstats/en/statistics/country_profile/profile.jsp?code=UZ

The number of scientific and technical journal articles[60] increased from 277.7 in 2003 to 357.4 in 2016, although they fluctuated substantially, according to the World Bank collection of development indicators (Figure 13).[61]

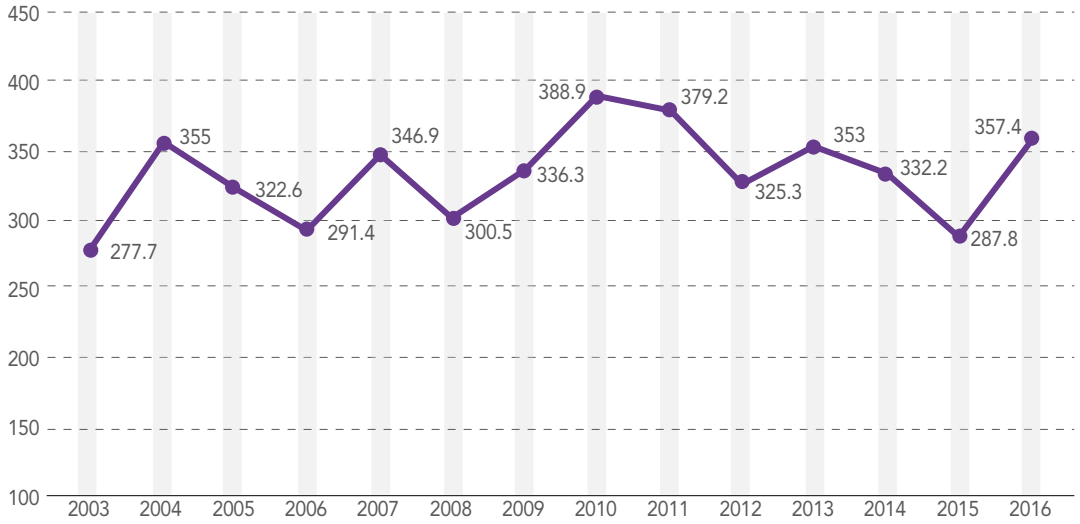


Figure 13. Scientific and technical journal articles in Uzbekistan (2003–2016)
Source: World Bank, https://data.worldbank.org/indicator/IP.JRN.ARTC.SC

60 Scientific and technical journal articles refer to the number of scientific and engineering articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences.
61 https://data.worldbank.org/indicator/IP.JRN.ARTC.SC

3.2. STI POLICY

The current STI policy of Uzbekistan is defined in the Presidential Decree No. PD-5544 'On Approval of the Strategy for Innovative Development of the Republic of Uzbekistan for 2019–2021'.[62] Adopted in September 2018, the strategy mainly includes the key STI-related challenges facing Uzbekistan, the strategic initiatives identified to address them and quantitative targets to be achieved by 2030.

The main challenges for STI development are described as insufficiencies in innovative development, modernization and diversification, and the increase in production volumes and expansion of competitive goods in the domestic and foreign markets. It also identifies the following weaknesses in the national STI system as hampering accelerated innovative development, investment, economic growth and progress in the other areas of state and public life:

- Insufficient number of population with a higher education degree.
- Lack of independence among higher education institutions in the definition of curricula and programmes, student admissions quotas and distribution of financial resources.
- Weak interaction between ministries and departments responsible for the development of scientific and innovation activities; weak coordination of research institution and laboratory activities.
- Low level of commercialization of research results.
- Absence of highly qualified specialists in the field of innovation management to facilitate the promotion and implementation of technology transfer.
- Lack of funding for R&D.
- Inefficiency and non-transparency of state funding for scientific and innovation activities; lack of mechanisms to attract extra-budgetary and private funds; insufficient development of internal sources of debt financing.
- Inadequate protection for the results of intellectual activity; lack of qualified specialists in this field, especially in government bodies.
- Low level of implementation of innovative technologies in the field of renewable and alternative energy sources, and energy recycling from secondary resources.
- Underdeveloped corporate relations and corporate governance principles in the country that take account of international best practices, especially in state-owned companies.
- Low share of the information and communication technologies (ICT) sector in the country's GDP.

The main goal of the strategy is to develop human capital as the key factor in determining the level of the country's competitiveness in the global arena and its innovative progress. To achieve this goal, the following objectives have been set:

- Securing a position among the top 50 countries in the Global Innovation Index by 2030.
- Improving the quality and coverage of education at all levels; developing a system of continuing education; ensuring flexibility of the personnel training system based on the needs of the economy.
- Strengthening the potential and effectiveness of scientific R&D; creating effective mechanisms for the integration of education, science and entrepreneurship for the wide implementation of R&D results and technological work.
- Increasing public and private investment in innovation, R&D, experimental design and technological work; the introduction of modern and effective forms of finance measures in these areas.
- Increasing the efficiency of public authority activity through the introduction of modern management methods and tools.
- Ensuring the protection of property rights, the creation of competitive markets and equal conditions for doing business; development of a public-private partnership.
- Creating a sustainable social and economic infrastructure.

62 https://lex.uz/docs/3913186

The strategy identifies five main areas for innovation-based development:

a. The development of science, inventiveness and technology transfer

- Introduction of a mechanism for state-funded research to carry out R&D on a programme-target basis, using project management models.
- Implementation of a set of measures to attract young people to scientific activities.
- Creation of centres for collective use of unique scientific and technical equipment.
- Increasing the prestige of scientific activity in the Republic of Uzbekistan.
- Creation of a state system of scientific and technical information, including national, sectoral and regional scientific and technical information resources and organizations specializing in the collection, storage and processing of domestic and foreign sources of scientific and technical information, the formation, maintenance and use of information funds, databases and data banks.
- Improvement of mechanisms for the evaluation of intellectual property objects.
- Creation of national and regional technology transfer offices.
- Creation of a hub of technoparks, free economic zones, free industrial zones, small industrial zones, and research and production clusters for the development and implementation of advanced technologies.
- Strengthening of state support for the formation of joint organizations with foreign partners for the production of domestically produced high-tech products and their implementation in foreign markets.

b. Improvement of the system for financing innovative activities

- Increasing public spending on R&D, bringing this up to 0.8% of GDP by 2021.
- Creation of special institutions for financing innovative activities (innovation funds, innovative banks, venture funds).
- Simplification of procedures and requirements for obtaining bank loans to stimulate innovative development in the country.
- Improvement of the system of micro financing for innovative development.
- Encouraging private sector participation in identifying and financing the priorities of scientific and technological development.
- Creation of a constantly updated single database of innovation projects and potential investors.
- Simplification of procedures and increased transparency in the receipt and use of grants and technical assistance for innovative projects.

c. Development of infrastructure and ICT

- Improvement of the normative legal regulation of the telecommunications sphere, to include expanding the participation of business entities through public-private partnership.
- Increasing the share of exports of ICT services to 4% of the total volume by 2021.
- Liberalization of access to direct connection to international telecommunications networks for all operators.
- Encouraging the population to use ICT.
- Development of the domestic software development industry through the creation of a technopark for startup projects.

d. Improvement of the education system and development of human capital

- Further improvement of the quality of education in educational institutions through the introduction of new educational programmes; modern pedagogical and smart technologies in the educational process, e.g. through the formation of electronic modules; introduction of distance learning.
- Development of inclusive education in order to provide conditions for equal access for children with disabilities.

- Creation of a 'barrier-free environment' through the installation of lifting devices, ramps, special devices in sanitary rooms, handrails, special desks, tables and other special compensatory means in educational institutions.
- Creation of integrated education programmes for children with special needs.
- Providing educational institutions with the necessary human resources, e.g. defectologist, specialists in psychological and pedagogical support for children.
- Development and implementation of a national system for assessing the quality of education and its impact on the innovative development of the country through systematic monitoring of the results of the educational process at the regional and national levels.
- Organization of short-term training in professional colleges for young people, in order to meet the changing trends in the labour market.
- Increasing the coverage of the population in higher education.
- Increasing the share of students in natural and technical sciences.
- Strengthening the research component of higher education institutions on the basis of state support for the most active universities in this field, selected according to the number of published scientific articles, citation index, participation in international conferences and seminars, and the number of obtained patents.
- Creation of foresight centres in leading universities as a separate link in the system of forecasting innovative activity, in order to develop proposals for the scenarios of industry and regional economy; providing scientific and technological forecasting for the internal and external environment; development of the technological and innovation environment, and the priority innovation goals of higher education institutions.

e. Development of competition and reduction of administrative barriers

- Development of corporate law and introduction of modern principles of corporate governance, taking into account international experience.
- Formation of a competitive market that stimulates the transition of the economy to an innovative way of development and efficient use of resources.
- Improvement of antimonopoly policy, including through the introduction of public-private partnerships, ensuring non-discriminatory access to goods, works and services of natural monopolies for all legal entities and individuals; introduction of effective pricing mechanisms for monopoly products.
- Creation of equal conditions for entrepreneurial activity and prevention of monopolization of the domestic market.
- Ensuring full digitalization of the state land registry by 2021 and simplifying the procedure of property registration.
- Increasing the share of electricity production from renewable and alternative energy sources to over 20% by 2025.

The strategy includes a roadmap with 35 actions defining the planned activities, deadlines, responsible institutions, sources of finance and expected results, as well as a table including 81 indicators and targets to be achieved by 2030. The list of measurable targets covers *inter alia* UIS, STI and education indicators, all World Bank governance indicators, selected Doing Business indicators and private sector development indicators. They are grouped under the following categories: (a) state building, (b) human capital development and research, (c) infrastructure development, (d) market development, (e) business development, (f) science and technology, (g) development of creative results.

Other recent legislation has implications for STI policy, as explained below.

3.3. LEGAL FRAMEWORK FOR STI

To support the implementation of STI policies and strategies, several decrees were issued, beginning in 2017. A significant recent development in the area has been the endorsement of the law 'On Science and Scientific Activities'. A similar law for innovation activities was drafted and is expected to be approved by Parliament.

Endorsed by the president on 29 October 2019, the law 'On Science and Scientific Activities'[63] emphasizes freedom of scientific creativity and information; efficiency and creative competition; interest and stimulation; objectivity of scientific expertise; not causing harm to human life and health, or the environment. It defines key objectives for science and scientific activities in order to achieve competitiveness and efficiency in the national economy, facilitate the formation of an aspirational and attractive environment for science, the involvement of young people in scientific activity, the close integration of science, education and production and the development of international cooperation in this field. It secures the powers of the Cabinet of Ministers, the Ministry of Innovative Development, the Academy of Sciences, universities, local government bodies, citizens, NGOs and other structures in the area.

The law seeks to integrate science with education and productive sectors, and foresees attracting young people to science and research through the development of government programmes, efforts to identify and educate talent, setting up of specialized schools, special classes, centres and training courses. It also requires that priority areas for S&T are developed, in order to provide a scientific means of achieving competitiveness and efficiency in the national economy, increasing labour productivity, creating new industries, and improving the quality of life of the population, as well as the systems of science and education. In addition, the principles of financing science and scientific activities are defined in the law.

In a specific article, the law emphasizes the need for commercialization of the results of scientific activities, and defines the routes for the transfer of knowledge and technology to the economy.

The draft law 'On Innovative Activities' aims to regulate the relationship between the subjects of innovation, public authorities and consumers of innovative products. It defines the main goal of innovation policy as creating favourable conditions for innovation, including the effective use of the country's scientific and technical potential, and the implementation of the results of scientific and technical work in order to solve national socio-economic development problems and increase the competitiveness of the economy. The main principles of the state innovation policy are the free implementation of innovation; the protection of intellectual property created as a result of innovation; the integration of innovation, investment, scientific and educational activities to ensure the effective interaction of science, education and production; and the allocation of budgetary funds on a competitive basis for the implementation of innovative projects.[64]

Below is a summary of the key legislation issued since 2017 that defines the STI system and the policy framework in Uzbekistan:[65]

- The Presidential Decree 'On the Formation of the Ministry of Innovative Development of the Republic of Uzbekistan' (UP-5264), dated 29 November 2017, sets out *inter alia* the key aims for the innovative development of the country, and forms the legal basis for the creation of the Ministry of Innovative Development (MoID), as well as the 'Fund for the Support of Innovative Development and Innovative Ideas'. From 1 January 2018, it also abolishes the State Commission on Science and Technology, the Agency for Science and Technology and the Fund for Support and Development of Scientific and Technical Activities under the State Commission on Science and Technology and its Executive Directorate, and transfers the staff in these institutions to the MoID. [66]
- The Decree of the Cabinet of Ministers 'On Measures to Create Effective Mechanisms for Introducing Scientific and Innovative Developments and Technologies into Production' (No. 24), dated 12 January

63 https://www.lex.uz/docs/4571492
64 https://www.gazeta.uz/ru/2018/03/05/innovation/
65 A list of relevant decrees is available on the website of the Ministry of Innovative Development: https://mininnovation.uz/en/menu/ukazy-postanovlenija-i-rasporjazhenija-prezidenta-respubliki-uzbekistan
66 http://lex.uz/docs/3431993

2018, defines *inter alia* the creation of mechanisms to ensure the effective implementation of the results of scientific research and innovative developments in production; the financing of expenses for the maintenance of buildings and structures, as well as the remuneration of certain categories of employees of research institutions (RIs) of the Academy of Sciences; the creation of a 'Fund for Supporting Innovation Activities' (without the formation of a legal entity) in economic management bodies and large state enterprises by allocating 10% of the net profit of these entities.[67]

- The Decree of the Cabinet of Ministers 'On the Approval of the Model Regulation on the Fund for Supporting Innovation Activities in Economic Management Bodies and Large State-Owned Enterprises' (No. 195), dated 12 March 2018, approves the regulation model of the 'Fund for the Support of Innovation in economic management bodies and large state enterprises'.[68]
- Issued on 7 May 2018 as a Presidential Decree, 'On Additional Measures to Improve Mechanisms for Introducing Innovations in Sectors and Spheres of the Economy' (PP-3698) introduces the post of vice-rector for scientific work and innovation in higher educational institutions; deputy directors for science of RIs of the Academy of Sciences; and the Office for the Development of Science and Scientific and Technical Research in the MoID. It also defines the sources for the 'Fund for Supporting Innovative Development and Innovative Ideas', established by Decree No. UP-5264, and requires that the Ministry of Finance, together with the State Investment Committee, ensures timely financing of the programme of comprehensive measures to strengthen the infrastructure of RIs and the development of innovative activities for the period 2017–2021. It accepts the proposal of the Ministry of Finance and the MoID for the allocation of 0.1% of funds from innovation support funds of economic management bodies and large state enterprises to the 'Fund for Supporting Innovative Development and Innovative Ideas'.[69]
- The Decree 'On the Additional Measures for the Enhancement of Commercialization of the Scientific and Technical Activity Results' (No. 3855), dated 14 July 2018, sets out a framework for the commercialization of research results from the institutes of the Academy of Sciences and universities.[70]
- 'On Measures to Improve the Efficiency of the System of Integration of Scientific and Innovative Activities' (PP-3899), a Presidential Decree dated 6 August 2018, primarily creates a new position at the MoID – the Deputy Minister in charge of the Department for Commercialisation and Transfer of Scientific Developments and Technologies. It also sets out the framework for establishing the Scientific and Technical Centre under the Academy of Sciences, in order to support the implementation of fundamental and applied scientific research for military, agriculture and other industries, and collaboration with universities.[71]
- Issued on 24 November 2018, the Presidential Decree 'On Additional Measures to Improve Mechanisms for Financing Projects in the Field of Entrepreneurship and Innovation' (UP-5583) defines the criteria, type of activity and monitoring of investment and management companies, including those to be created for venture financing.[72]
- The Decree of the Cabinet of Ministers 'On the Organisation of Activities of the Republican Council on Science and Technology' (No. 953), dated 27 November 2019, defines the composition and regulations of the Republican Council on Science and Technology, as well as the rules for accepting recommendations and preparing proposals for candidates for the State Prize of S&T

67 http://lex.uz/docs/3506460
68 http://lex.uz/docs/3584368
69 http://lex.uz/docs/3723559
70 https://lex.uz/docs/3823592
71 http://lex.uz/docs/3853774
72 http://lex.uz/docs/4076954

4. STI system in the Republic of Uzbekistan

4.1. STI SYSTEM

The STI system of Uzbekistan is in the process of formation as a result of the recent innovation-focused developments. As noted above, the legislation issued over the last three years defines the key stakeholders and their roles in the NIS. The roles and responsibilities of the key actors of the NIS are explained below.

According to the Law 'On Science and Scientific Activities', the high-level policy-making body for STI is the Cabinet of Ministers. Its relevant tasks include ensuring the implementation of the main directions of science and scientific activity, approving priority areas for the development of S&T and ensuring the formation of the S&T infrastructure, among other things.

The Republican Council on Science and Technology, established by Decree No. 953, is defined as an advisory body for the development of S&T and the improvement of higher education. Its aim is to ensure interaction between government organizations, business associations, local government bodies, and scientific and educational institutions. Its tasks include *inter alia* the design of national S&T policy and coordination of ongoing reforms in the field of science and education, the development of effective measures to accelerate the development of S&T, and ensuring the effectiveness of their implementation. The Council is composed of 29 members, including the prime minister who acts as the chairperson. The head of the Secretariat of the Cabinet of Ministers was appointed as the Secretary of the Council. It is required to convene at least every six months and the members take part in its activities on a voluntary basis, as stated in the decree.

In order to lead the innovation-driven development of the country, the MoID was created in November 2017 as an initiative of the President via the Decree of the President of the Republic of Uzbekistan (No. УП-5264 and No. ПП-3416).

The ministry has been given the following responsibilities:[73]

- Implementation of a unified state policy in the field of innovative and scientific and technical development for the Republic of Uzbekistan, aimed at comprehensive development of public and state life, increasing the intellectual and technological potential of the country.
- Using effectiveness indicators to evaluate innovative activity, in order to determine the main directions of relevant industries and identify areas requiring priority implementation of advanced technologies.
- Coordination of the activities of government, research, information and analytical institutions and other organizations on the implementation of innovative ideas, developments and technologies.

The law 'On Science and Scientific Activities' appoints the MoID as the official state body in the field of science and scientific activity, and assigns the following responsibilities:

- Implementing the main directions of science and scientific activity.
- Forming priority areas for the development of S&T.
- Coordinating the development activities of government bodies, scientific organizations, higher education, information and analytical institutions and other organizations in the field of science and scientific activity.
- Developing and approving state programmes for scientific activity, state target programmes for scientific activity and monitoring their implementation; coordinating the development of regional programmes for scientific activity.
- Holding a project competition within the framework of state programmes for scientific activity, and financing them.
- Forming a state order for scientific projects, maintaining state accounting, monitoring project implementation and receiving project reports.
- Forming and approving the list of unique scientific objects.

73 https://lex.uz/docs/3431993

- Assisting in the development of international and mutually beneficial scientific cooperation, and in attracting foreign investment in the field of science and scientific activity.
- Coordinating the training system with degrees.

Along with the MoID, other key ministries, most notably the Ministry of Economics and Industry, the Ministry for Development of Information Technologies and Communications, and the Ministry of Higher and Secondary Special Education assume important roles in the innovation-driven transformation of the country.

The Ministry of Economics and Industry is the main body for overseeing economic growth and is responsible for the development and implementation of long-term strategy and integrated development programmes. It has a specialized unit on Science and Innovation, created as a result of the recent prioritization of STI in the government agenda. The ministry is also responsible for the coordination of actions related to the SDGs. Other key roles played by the ministry in STI-driven development include the policies and programmes for SMEs and clusters.

The ministry also operates an electronic cooperation portal[74] for finding partners, establishing economic relations and creating a stable demand for domestic producers through the public procurement system. The portal aims to further expand domestic industrial production, promote the involvement of small businesses in industrial activity, and strengthen and develop industrial cooperation. As of January 2020, there are 18,624 enterprises registered on the portal (26.4% of the total number of enterprises in the country).

The Ministry for Development of Information Technologies and Communications leads development in the ICT sector and infrastructure, digital transformation and e-government. It is comprised of ten entities, including Uzbek Telecom and the Post Office, and 10% of their profit is spent on supporting R&D in start-up companies. In 2019, the ministry created the IT Park in Tashkent. There are three universities under the ministry – the Tashkent University of Information Technologies named after Muhammad Al Khorezmiy (TUIT); the Inha University in Tashkent, a branch of Korean Inha University; and the Amity University Tashkent, a branch of Indian University. All three universities have a strong focus on ICT research. The TUIT has some 400 researchers with doctorate-level degrees and the others plan to launch Ph.D. programmes.

In November 2019, the ministry initiated a project called 'One Million Uzbek Coders' together with the United Arab Emirates (UAE).[75] Launched at the Inha University in Tashkent, it provides free distance learning for young people in four IT specialties, namely: data analytics, android development, front end development and full stack development. It is implemented in partnership with the Dubai Future Foundation, Inha University in Tashkent, the IT Academy and the IT school named after Muhammad al-Khwarizmi. The training programme is open to anyone over 13 years of age and lasts 120 hours. Successful graduates will be given the opportunity to compete for grants and continue their studies on one of the Udacity Nanodegree programmes.[76] The project is considered as a means to provide job opportunities for unemployed young people by equipping them with the necessary ICT skills to start working as freelancers.

A public sector innovation award organized by the ministry (the so-called 'mGov Award') aims to encourage the younger population to undertake innovation and entrepreneurship.[77] Created jointly by the government and UAE, it encourages students to collaborate and co-create, using government mobile applications, to improve public services. The total prize money is USD 100,000, and will be awarded to three winning teams in March 2020.

Another ministry programme involves the establishment of 'learning and technology centres' to train young people in ICT and help them develop business ideas. Coordinated by the IT Park, the programme envisages the creation of 200 centres by 2022.

74 http://cooperation.uz/
75 http://uzbekcoders.uz/?lang=en
76 https://www.udacity.com/
77 https://mgovaward.uz/

Furthermore, the development of space technologies falls within the remit of the ministry. It aims to establish the Space Research and Technology Agency (Agency 'Uzbekcosmos') in 2020 and then transfer its role in this sector to the agency. The ministry plans to launch the first national satellite in three years and to collaborate with Germany for this purpose. It gave the responsibility of developing human capital on space communication technologies to the Tashkent University of Information Technologies. The University, despite playing an important role in the development of emerging technologies in Uzbekistan, lacks the required research infrastructure, in particular new laboratory infrastructure for space communication technologies, as well as for its R&D centre on artificial intelligence (AI). The space communication technologies laboratory is needed not only to implement the plans for launching the first national satellite but also to develop the required human capital through postgraduate programmes for the Agency 'Uzbekcosmos'. The R&D Centre on AI was established by presidential decree to implement R&D activities on AI and to offer postgraduate courses.

As a key player on the research performance side of the NIS, the Academy of Sciences of Uzbekistan takes the lead for R&D activities. Established in 1943, it covers a number of areas, such as fundamental and applied research, innovation projects and training courses for highly skilled staff, and is composed of 32 institutions, including 23 institutes, one interdepartmental research centre and four museums.[78] The new law 'On Science and Scientific Activities' empowers the academy to undertake the following duties:

- Making proposals on defining priority areas for the development of S&T and state scientific programmes, as well as international programmes.
- Defining and implementing measures to ensure the close integration of science, education and production.
- Creating the necessary conditions for subjects of scientific activity related to the use of centres for the collective use of scientific equipment, unique scientific objects in the manner established by law.
- Increasing the potential of scientific organizations and preparing cadres for a scientific degree.
- Promoting the commercialization of scientific developments and encouraging their creators; creating the necessary conditions for attracting young people to scientific activities.
- Representing employees of scientific organizations for state and international awards.
- Studying, analysing, popularizing and promoting the achievements of domestic and overseas science; developing recommendations for their use in the interests of Uzbekistan.
- Helping to establish cooperation with foreign academies of science, scientific organizations and foundations; organization of international scientific events.

The government has recently improved the infrastructure of the RIs of the academy as well as working conditions, including the salaries of their researchers and other employees. Since 2018, nearly USD 7 million has been invested in strengthening and renewing the laboratories of the RIs. Several other measures have also been taken to strengthen the academy, such as providing young researchers with state housing, improving the election system, providing all RIs with finance from the state budget and providing them with the opportunity to apply to the MoID for additional funding if necessary. In addition, ten RIs which were previously entrusted to the Ministry of Higher and Secondary Specialized Education have been re-transferred to the academy. All these developments have started to improve not only the status of the academy but also of science and research, especially among young people.

As the commitment to invest in research commercialization increases, the need to institutionalize technology transfer activities has arisen in the academy. Although, currently there is a very small unit acting as a bridge between science and industry, there are plans to create a separate department for commercialization of research results.

The Centre for Scientific and Technical Information, established on 11 December 2019 by order of the Minister of Innovative Development under the MoID, aims at improving the state system of scientific and technical information. During the initial stage, the centre has four main tasks: (1) the formation of databases of scientific and technical information and a comprehensive analysis of the effectiveness of scientific and

78 http://www.academy.uz/en/page/biz-haqimizda

innovative activities in the country; (2) preparation of materials for the annual National Report on Innovative Development of the Republic of Uzbekistan; (3) development of effective mechanisms for conducting scientific and technical expertise submitted for financing R&D projects with the involvement of foreign experts; and (4) the development of international cooperation in the exchange of scientific and technical information. In addition, the centre will be engaged in the preparation of data and indicators necessary for the implementation of international assessment procedures and cross-country comparisons on the level of development of science and innovation. From the point of view of managing the development of scientific and innovative activities, the centre will play a key role in implementing high-quality information support for strategic and operational decision-making processes.

Another strategic organization created under the MoID is the Centre for Advanced Technologies (CAT). It was established in 2018 via the Presidential Decree 'On formation of the Centre for Advanced Technologies under the Ministry of Innovative Development of the Republic of Uzbekistan'[79] (No. PP-3674) and aims to create conditions for enhancing the development of scientific and innovative activities; to further ensure wide integration of science, education and production; the generation and application of new knowledge; the effective use of scientific and innovative potential and the scientific and laboratory base in the development and implementation of advanced innovative ideas, technologies and projects. The CAT conducts research and offers R&D and testing services to the public and private sector in a number of scientific and technological fields in its laboratories of biotechnology, geophysics and nanomineralogy, screening and molecular interactions, and physio-chemical research methods. It also implements an acceleration programme for science-based start-ups (the so-called CAT Science Accelerator), where potential entrepreneurs undergo a six-month training course as well as having free access to its laboratories. By mid-2019, the CAT received 130 applications and selected 28 teams for the acceleration services. At the end of the process, ten teams applied for project financing.

Other notable research and education bodies in the Uzbek innovation system include the higher education institutes and their research centres, as well as the RIs of the Ministry of Agriculture, the Ministry of Health, the State Committee on Land Resources, the State Forestry Committee and the State Veterinary Committee.

STI infrastructures, such as technology parks, innovation centres and business incubators, also exist and the government currently takes steps to improve their effectiveness and impact. The majority of these infrastructures are concentrated in Tashkent. However, the government seeks to promote regional development and reduce regional disparities through support to innovation. It is in the process of creating innovation centres across the country as a measure to address this need.

The two technology parks of Uzbekistan, the Technopark 'Yashnabad' and the IT Park, are located in Tashkent. With the Presidential Decree 'On the creation of an innovative technology park in the Yashnabad district in Tashkent' (No. UP-5068), dated 5 June 2017, the territory of Tashkent is conditionally equated to the innovation zone. According to the decree, any enterprise intending to produce innovative products in Tashkent can apply for the status of resident of the Yashnabad technology park. The tenants are provided with benefits in the form of tax exemption for up to ten years, and preferential loan rates of 7%, among other advantages.[80] The priority focus areas for the technopark are chemical technology, biotechnology, pharmaceuticals and medical biotechnology and plant protection products; materials science, metal processing technologies, earthquake resistance and building materials; food industry, energy conservation, production of alternative and renewable energy sources; and electronic measuring instruments, robotics, mechanical engineering and electrical engineering.[81] As at January 2020, there are 21 tenant companies.[82]

Created in July 2019, the IT Park focuses on software products and information technologies.[83] It was established by the Ministry for Development of Information Technologies and Communications, together with the Software Technology Parks of India (STPI). The STPI provides consultancy for applying India's

79 https://lex.uz/docs/3693981
80 http://www.yait.uz/
81 https://lex.uz/docs/3227416
82 http://www.yait.uz/residents?page=1
83 https://lex.uz/docs/4152134?query=%D0%BF%D0%B0%D1%80%D0%BA

best practices in the development of technology parks and supporting software developers. In addition to quality office space, equipment and facilities, tax and customs exemptions are provided to the tenants. The park is located at the Al-Khwarizmi school in the Mirzo-Ulugbek district, near Tashkent Inha University, and includes business incubation, acceleration and venture fund programmes. It has been merged with the Mirzo Ulugbek Innovation Centre, which was established in 2017 by the government to develop the ICT sector in Uzbekistan. The main goal of the IT Park is defined as creating a start-up ecosystem to support the development of the export-oriented sector. To this end, partnerships are established with local and international organizations, such as Tech Nation in the UK, IT start-up tech park Astana in Kazakhstan, IT parks of Moscow in Russia, Inha University in Tashkent, and Tashkent University of Information Technologies. There are plans to open new blocks of the park in the future. In addition, the ministry plans to create branches of the IT Park in other regions of Uzbekistan to develop IT start-ups.

There are also other infrastructures created recently, such as the State Unitary Enterprise 'Geoinnovation Centre'. Established in 2018 by the Presidential Decree dated 29 March 2018 (No. PP-3639), the centre is a sub-enterprise of the State Committee of the Republic of Uzbekistan on land resources, geodesy, cartography and the state land registry. It is responsible for the implementation of automated technologies in the country and expanding the use of automated aerial vehicles in the economy.

There are 20 technology and innovation support centres (TISCs), established in universities and research institutes under a project implemented with the WIPO between November 2017 and December 2019. The TISCs aim to stimulate innovation and economic growth by facilitating access to technological information and by strengthening the country's capacity to effectively exploit this information. The first step includes training the TISC staff, providing them with access to patent and non-patent information databases and improving specialist skills in this area. The second step includes assistance in obtaining international protection for patents under PCT, and patent commercialization including international advancement.[84]

On the policy implementation side, several bodies exist, such as the Scientific and Practical Centre for the Implementation of Innovative Projects and the National Agency for Project Management (NAPM). Established as a sub-organization of the MoID, the Centre seeks to promote the development of innovation, ensure the transfer of research results through technology licensing, and the creation of spin-offs, among other things. The NAPM, formed under the President of the Republic of Uzbekistan, acts *inter alia* as the official body for the development of the digital economy. It manages the Fund for Support of Digital Economy Development ('Digital Trust'), which was established in 2018 to accumulate investments for the development and implementation of the digital economy and blockchain-related projects, and to support training events as well as start-ups in the field of blockchain, among other things.

The NAPM also implements pilot projects to test the feasibility of the application of emerging technologies in different sectors. One such project has been carried out together with the State Committee of the Republic of Uzbekistan on land resources, geodesy, cartography and the state land registry to introduce digital solutions for the agricultural industry, and involved the use of an agrodron with digital multispectral cameras for monitoring the agro-industrial complex to increase productivity. For the purposes of high-quality implementation and continuous application of new technology, the Digital Cadastre LLC was established under the state unitary enterprise 'Geoinnovation Centre'.[85]

The NAPM was also tasked with creating an innovation area, the so-called 'International High-Tech Innovation Centre' ('Delta city') in Tashkent, in accordance with the Presidential Decree (No. PP-3833), dated 4 July 2018.[86] The 'Delta city', which is estimated to cost USD 1.5 billion, will be provided with special fiscal incentives for investors until July 2021, and will include a research institute and a student campus, as well as multifamily and free-standing residential buildings.

84 https://www.wipo.int/tisc/en/search/list.jsp
85 https://napm.uz/en/press_center/news/napm-launches-technology-to-increase-crop-productivity-through-agrodrons/
86 https://lex.uz/ru/docs/3806160

Finally, the Agency on Intellectual Property under the Ministry of Justice, the State Committee of the Republic of Uzbekistan on Statistics, and the Agency for Standardisation, Metrology and Certification of Uzbekistan are among the main building blocks of the NIS. The latter also established the Centre for Accreditation in 2018, in accordance with the Presidential Decree No. 3643. Efforts are also ongoing to create other key elements of the system. For instance, the Export Promotion Agency was formed under the Ministry of Investments and Foreign Trade, in accordance with the Presidential Decree dated 20 December 2018 'On Measures to Enhance Export Promotion' (No. PP-4069), and there are also plans to establish an SME and entrepreneurship development agency.

In addition to its efforts to invest in research, innovation and research commercialization, the government is taking action in the field of public sector innovation. The Centre for Economic Research (CEI) is one of the leading institutions in this domain. Established in 1999 by the government with the assistance of the United Nations Development Program (UNDP), it not only acts as a think tank but also designs and implements projects to facilitate socio-economic development. One of the projects initiated by the end of 2019 is the 'Government accelerator', implemented with the UAE to improve public sector governance and solve issues related to public services within 100 days, together with the relevant stakeholders. The CEI is also responsible for the analysis of complaints collected from citizens about the areas which require improvement. So far, some 3.5 million complaints were collected through an online system and the top three issues were identified as housing, employment and social benefits.

Uzbekistan has several key institutions which act as innovation intermediaries for the private sector. Among them are the Chamber of Commerce and Industry, free economic zones (FEZs) and small economic zones (SEZs). The chamber is a key intermediary organization and service provider for the growth of the private sector. Its priorities include the implementation of market rules, developing capabilities for innovation management tools (such as kaizen, just-in-time, quality standards, etc.), and capacity building in businesses and human resources development through different means including international study visits. The chamber also helps SMEs to identify and acquire technologies.

Established by the Presidential Decree of 26 October 2016 (No.DP-4853), the FEZs are provided with exemption from taxes and customs duties, as well as from mandatory contributions to the government. These benefits are provided for a period of 3–10 years, depending on the level of investment made. Several SEZs in the country host manufacturing businesses and offer exemption from unified tax and customs duties for 2–3 years.

The clusters conceptualized in different regions and sectors also have to the potential to play an intermediary role for innovation between the public and private sector. The development of clusters as a tool to promote economic growth in regions is high on the government agenda. Several cluster initiatives have already been launched, mainly with other countries, such as the cotton cluster in Samarkand province developed with South Korea, and the seed production cluster with India. The Ministry of Economics and Industry is also pursuing the development of a stevia cluster, which is considered to have high potential for the country. On the other hand, there are not yet any public support programmes and policies for the development of clusters.

4.2. OVERVIEW OF THE STI ORGANIZATIONAL STRUCTURE

Policy-planning level (policy design):

- Republican Council on Science and Technology
- Ministry of Innovative Development
- Ministry of Economics and Industry
- Ministry for Development of Information Technologies and Communications
- Ministry of Agriculture
- Ministry of Health
- Ministry of Higher and Secondary Specialized Education
- Ministry of Public Education
- Ministry of Justice

Promotional level (funding):

- Ministry of Innovative Development
- National Agency for Project Management
- Venture capital funds and other private sources of innovation finance

Performance level (scientific research, technological development and productive innovation):

- Research institutes of the Academy of Sciences
- Research institutes of the Ministry of Agriculture, the Ministry of Health, the State Committee on Land Resources, the State Forestry Committee and the State Veterinary Committee
- Research centres of universities
- Centre for Advanced Technologies
- Private sector

Science and technology services:

- Technopark 'Yashnabad'
- IT Park
- Technology and Innovation Support Centres
- Innovation centres
- Business incubators
- Accelerators
- State Unitary Enterprise 'Geoinnovation Centre'
- Agency on Intellectual Property
- State Committee of the Republic of Uzbekistan on Statistics
- Agency for Standardisation, Metrology and Certification of Uzbekistan
- Export Promotion Agency
- Chamber of Commerce and Industry
- Free Economic Zones
- Small Industrial Zones
- Centre for Economic Research

Assessment/ evaluation level:

- Centre for Scientific and Technical Information

4.3. OPERATIONAL STI POLICY INSTRUMENTS

Most R&D funding is provided to the scientific community in Uzbekistan. The funding system has been improved by the MoID since 2018. According to the new system, finance is provided on a competitive basis through calls announced every two months in line with the priorities of the country and needs of the industrial sector. Unlike the previous system, where funding was mainly used to cover the salaries of researchers, the MoID started to finance the procurement of R&D equipment as well (at least 50% of the project budget). The upper limit for project budgets has also been increased to USD 80,000.

The MoID manages two funds to support STI in the country: the 'Fund for Supporting Innovative Development and Innovative Ideas' and the 'Presidential Fund for the Commercialisation of the Results of Scientific and Scientific-Technical Activities'.

The 'Fund for Supporting Innovative Development and Innovative Ideas' finances *inter alia* the establishment of new research laboratories and the procurement of modern scientific equipment in RIs and higher education institutions; registration of international patents created as a result of public support programmes; access to electronic scientific databases; short-term scientific internships for young scientists in leading foreign scientific organizations; and expenses such as labour and transportation costs for highly qualified foreign scientists and specialists involved in research and related activities in the country.

The 'Presidential Fund for the Commercialisation of the Results of Scientific and Scientific-Technical Activities' finances the commercialization activities for the research results by selling products/services developed, by creating spin-off companies, or by licensing IP to third parties.

In order to develop STI human capital, a programme for supporting international internships for researchers from 3 months to 3.5 years has been implemented. In 2018–2019, 300 researchers were sent abroad and another 250 selected for the same scheme in 2020. The MoID also supports bilateral research projects with universities and RIs in China, Germany, Turkey, Belarus, Russia and India.

In addition to direct funding, there are fiscal incentives provided to companies located in innovation infrastructures, such as technology parks and FEZs, as noted in the previous section.

The recent priority areas for the MoID include supporting start-ups and facilitating research commercialization. For the former, regional innovation centres are created and acceleration programmes are implemented, while for the latter the MoID works with the Academy of Sciences to identify and commercialize the technologies based on the needs of the industry. Since 2018, more than 100 scientific and innovative products and technologies have been commercialized in different sectors such as medicine, agriculture and ICT. The main issues in the process of commercialization are valuation of the intellectual property and management of the negotiation process.

The MoID is also taking steps to popularize science and support high-level decisions with practical actions. An example is given in Box 2 below.

BOX 2 – MOID'S LEADERSHIP IN THE PROMOTION OF SCIENCE YEAR

After the President's declaration of 2020 as the 'Year of Development of Science, Education and the Digital Economy' and the announcement of mathematics, chemistry, biology and geology as the scientific disciplines selected as the priority areas for 2020, the MoID assumed responsibility for creating research and innovation communities around these fields.

Currently, the MoID is leading several actions in this respect. For example, in order to stimulate the development of innovation ideas where mathematics can be used as a key input, First Deputy Minister Rajabbayev launched a group on the Telegram application on 8 February 2020 for an initial group of 25 experts and challenged them to come up with ideas and develop partnerships for their implementation. In less than one week, the number of members grew from 25 to over 1,400. Considering the increased interest and high-level interaction in the group, the ministry is considering creating a 'maths portal', where project ideas and offers will be shared and partnerships established. Physical meetings are also organized by the ministry with the members of the group for the same purpose. The first meeting was held on 15 February 2020 at the Uzbek-Japanese Youth Innovation Centre in Tashkent.

There are also programmes that have been designed and implemented with the support of international organizations to encourage STI in the higher education sector, including the UNDP- and World Bank-funded projects. The former, launched in January of 2016, helps Uzbek students and young scientists implement start-up ideas and realize their entrepreneurial potential by offering them training for a period of three months on the presentation of products and ideas to potential investors. The World Bank-funded project is implemented under a USD 42.2 million credit agreement, signed in April 2017, to modernize the higher education system and improve the quality of the labour market in Uzbekistan. It includes components to modernize university laboratories and research facilities, and to establish a national electronic library.

One of the components of the World Bank project is the creation of a USD 4 million Academic Innovation Fund (AIF) under the Ministry of Higher and Secondary Specialised Education, which higher education institutions can use for proposing new education initiatives. The fund aims to improve the relevance of higher education to the labour market by selecting and financing innovative projects to strengthen the institutional and material basis for improving university-industry links, teaching and learning practices and university environment, including through the funding of necessary teaching, learning and research material. It supports grant proposals in (i) strengthening university-industry links and (ii) improving teaching and learning practices within higher education institutions.[87] According to the stakeholders, the fund gives the opportunity to researchers with a relatively low level of experience in preparing research projects to apply and benefit from the research funding, as it is normally the experienced scientists who repeatedly apply for public funding for research.

87 http://documents.worldbank.org/curated/en/823401467999690136/pdf/PAD715-PAD-P128516-IDA-R2016-0062-1-Box394878B-OUO-9.pdf

5. Review of needs and opportunities for STI development

As Uzbekistan moves towards creating an innovation-driven economy, it needs to build up a fully-fledged national innovation system, pursue more effective STI governance, create a balanced STI policy mix and continue to invest in building STI capacities. The key related needs and opportunities, based on the desk and field research conducted under this study, are summarized in this section.

5.1. IMPROVING STI POLICIES, SYSTEM AND GOVERNANCE

Although Uzbekistan has a strategy for innovative development for the period covering 2019–2021, adopted in September 2018, it needs a holistic STI policy to be developed and implemented with the active involvement of the NIS stakeholders. Currently, in addition to the decree relating to the STI strategy, there is a range of legislation that concerns different aspects of STI policy, as explained above, as well as different projects and programmes designed and implemented with international organizations and governments. Putting in place an STI policy for the next ten years will help Uzbekistan to achieve greater harmonization and thus create a greater impact with these initiatives.

The innovation system of Uzbekistan is evolving rapidly and several elements are at a nascent stage. There is a need to avoid task duplication and fragmentation, and enhance coordination between NIS institutions. While the MoID plays a significant role in the development of the system, various STI-related roles are distributed among several other ministries, as explained in the previous section. Furthermore, although the recently created Republican Council on Science and Technology was given the role of high-level policy making and coordination, it is not clear how these roles will be coordinated between the Council and the Cabinet of Ministers, which was also assigned with similar tasks by the law 'On Science and Scientific Activities'. Moreover, the definition of the council as an advisory body, the voluntary approach to be taken by its members, and the lack of an organization appointed to assist the council in designing, monitoring and evaluating policies incapacitate it as an STI oversight body. Therefore, it is important to review and revise the council's legislation to empower it as a advisory institution for the coordination of the formulation and implementation of STI policies, to establish multistakeholder dialogue, design a coherent STI policy mix, and integrate STI into other policy areas. In the current set-up of the NIS, it is advisable that the MoID undertakes the role of the secretariat organization of the council, since there is a need to undertake comprehensive tasks for the effective management of the STI policy cycle and report to the council.

There is also a need for the creation of strategic institutions for better policy implementation. These include two multi-disciplinary programme implementation agencies in the form of a national innovation agency and a national science agency for the design and implementation of policy instruments, for innovation and research respectively, in line with international good practices. Such organizations do not depend on the annual state budget and therefore provide ongoing support to eligible research and innovation projects in the private sector, start-ups and universities/research institutes. They also become specialized in research and innovation programme design and implementation, and therefore have strategic capabilities in STI policy implementation. Examples of such agencies are given in Box 3 below. With the inclusion of these bodies in the NIS, it would be important to redistribute the roles and responsibilities among the stakeholders involved in the implementation of policies, strategies and measures for innovative development, taking into account principles such as the segregation of duties, transparency and coordination effectiveness. In this new setting, the MoID would position itself as the organization coordinating the STI policy cycle from design to evaluation, ensuring transparency and accountability of public support for STI, and eliminating any potential conflict of interest and overlaps in the system.

BOX 3 – EXAMPLES OF INNOVATION AND RESEARCH AGENCIES

- Sweden's innovation agency VINNOVA[88] is a key public actor for supporting innovation. It was founded in 2001 (as the successor of the innovation agency NUTEK) with the vision of turning Sweden into 'an innovative force in a sustainable world'. Its mission is to 'help to build Sweden's innovation capacity, contributing to sustainable growth'. The agency bases its work 'on the global sustainable development goals of the 2030 Agenda adopted by the United Nations'. Its annual budget allocated to support innovation is about SEK 3 billion (EUR 282 million). VINNOVA is also the national contact authority of the EU research and innovation framework programmes, as well as the government's expert authority in innovation policy. It employs over 200 people and in addition to its head office in Stockholm, it has affiliates in Brussels, Silicon Valley and Tel Aviv.

- Innovate UK[89] is the innovation agency of the UK. It aims to 'drive productivity and economic growth by supporting businesses to develop and realize the potential of new ideas, including those from the UK's world-class research base'. The organization has around 500 staff. Its support is 'available to businesses across all economic sectors, value chains and UK regions'. Since 2007, Innovate UK has provided funding amounting of approximately GBP 2.5 billion to help businesses across the country to innovate, with matched funding from industry taking the total value of projects above GBP 4.3 billion. With its innovation funding, it has 'helped 8,500 organizations create around 70,000 jobs and added an estimated GBP 18 billion of value to the UK economy'.

- ANR[90] is the French national research agency responsible for funding project-based research carried out by public organizations cooperating with each other or with private companies. Its support budget in 2019 was EUR 708.3 million. ANR's programmes are grouped under different categories, such as 'supporting early-stage research', 'developing partnership-based research and technology transfer', 'supporting urgent research needs', and 'encouraging the participation of French teams in European and international programmes'.

- JST (Japan Science and Technology Agency)[91] 'promotes research and development leading to innovation, and addresses economic and social issues through the implementation of research results and international joint research'. Its total project funding in 2019 was JPY 122,494 million (around EUR 1 billion). It has three main programmes for supporting 'strategic basic research', 'international collaborations' and 'industry-academia collaboration and technology transfer'.

- The SFI[92] (Science Foundation Ireland) is 'the national foundation for investment in research in the areas of science, technology, engineering and mathematics (STEM) to assist the development and competitiveness of industry, enterprise and employment in Ireland'. It was established in 2000 as a separate legal entity. In addition to its support programmes, SFI implements challenges such as the 'AI for Societal Good Challenge' and the 'Zero Emission Challenge'. Its annual capital grants budget for 2019 was EUR 188.25 million.

Dynamizing the NIS in Uzbekistan also requires encouraging the creation of innovation intermediaries and service providers to facilitate the creation, diffusion and use of knowledge, technology and innovation. To this end, promoting the creation of sectoral and thematic NGOs, cluster coordination units and private companies specialized in research and innovation management would be useful. Equally important is to strengthen the RIs, particularly those of the Academy of Sciences, by implementing a comprehensive reform programme. While the government has achieved significant progress in improving the RIs of the

88 https://www.vinnova.se
89 https://www.gov.uk/government/organisations/innovate-uk
90 https://anr.fr
91 https://www.jst.go.jp
92 https://www.sfi.ie/

Academy, there is a need to transform them in such a way that they strategically focus on and develop capacities for conducting result-oriented R&D, providing extension services, and transferring knowledge and technology for the benefit of society and the economy.

As rightly brought to the fore by the government recently, reducing the regional disparities in Uzbekistan and addressing region-specific challenges requires a specific focus on the development of local and regional innovation ecosystems. Therefore, policy actions such as the creation of regional innovation councils, the decentralization of research and innovation activities (including expansion of RIs of the Academy of Sciences to the regions), and the design and implementation of smart specialization strategies, taking into account the potential and strengths of each region, is of critical importance for the country.

Another significant issue that should be tackled by the policy is the high number of pilot projects and programmes in STI-related areas implemented in Uzbekistan. Since they are mainly carried out with international organizations and donor governments, their coordination, scale-up and sustainability pose challenges. The majority of such initiatives cease with the end of donor funding without creating the desired impact, even if they are proved to be feasible. It is essential that this issue is put at the top of the agenda by the policy-makers, and procedures, processes and criteria are developed for the selection, implementation, monitoring, evaluation and scale up of pilot STI initiatives.

Other key steps required to improve policy governance include the establishment of a single window to make information and guidance about the STI policy instruments available to research performers, entrepreneurs and the private sector; simplification of relevant legislation; and the streamlining of administrative processes for public STI interventions. The integration of a monitoring and evaluation (M&E) framework in the policy cycle, and the development and implementation of a M&E system for policies and policy instruments in line with international good practices (i.e. evidence-based ex-ante, interim and ex-post evaluations to be conducted independently and regularly), are also essential.

Finally, as noted in previous sections, the government is investing in public sector innovation and implementing projects with the involvement of different ministries and public agencies. These efforts also need better governance and coordination, as well as a strategic direction for ensuring that they yield positive results by using public resources efficiently.

5.2. DEVELOPING A BALANCED STI POLICY MIX

Currently, the majority of STI policy instruments in Uzbekistan concentrate on research performers and start-ups, with the primary focus being research commercialization, primarily through start-up projects. Thus, there is a need to develop and maintain a balanced policy mix, and to evaluate and improve the existing STI instruments, including STI infrastructures, and eliminate duplication and overlaps, if any. It is also essential to ensure that policy instruments not only address research performers or technology-based start-ups, but also target the private sector, notably SMEs, including those in the traditional sectors, and grass-roots innovators. Considering the challenges facing the country, it would be useful to put in place policy instruments to support social and inclusive innovation as well.

Designing and implementing a sectoral STI programme aiming to support R&D and innovation projects, particularly in health, agriculture and education, will be beneficial for Uzbekistan, as also noted by the MoID. In such a programme, the target beneficiaries could be defined as the private sector and the universities/RIs, and the projects developed either individually by these organizations, or by a group of entities (clusters of private companies, universities and research institutes) could be funded. The projects could aim either to develop new products, services or processes, or to significantly improve existing products/services/processes, or solve common technical problems facing the sector (improving efficiency, enhancing quality, etc.).

The promotion of innovation clusters in regions as well as in the research hot spots of the capital is an opportunity for Uzbekistan to create greater impact with STI policies. Emerging clusters in and around

technology parks, FEZs[93] and SEZs, as well as integrated value chains of priority sectors, notably agro-food, tourism and ICT sectors, could be targeted at the beginning and the creation of cluster coordination units could be encouraged.

The diversification of funding mechanisms is needed to finance the STI activities of different target groups. For this purpose, while government support in the form of soft loans and grants should be made available for different beneficiaries, the development of private modes of finance should be stimulated, for example by creating a fund of funds mechanism for the development of venture capital industry, particularly to invest in innovative SMEs, establishing seed funds for start-ups and setting up an angel investors network. These measures should seek to facilitate the growth of start-ups and innovative SMEs supported by the policy initiatives.

For the effective design and implementation of policy instruments, it is necessary to establish good practices in programme design. This requires that for each policy instrument, problem tree, theory of change indicators and SMART targets,[94] a monitoring and evaluation framework be developed, processes described, rules and regulations defined and a complete set of programme documents prepared at the outset.

5.3. ENHANCING STI INFRASTRUCTURES

Enriching the innovation infrastructures in the country by establishing Fab Labs will help Uzbekistan to benefit from emerging technologies, both for production and educational purposes. Initiated in 2001 by the MIT, a Fab Lab is a technical prototyping platform for innovation and invention, providing stimulus for local entrepreneurship as well as for STEM education (see Box 4). It would be useful to start with the creation of a central stationary Fab Lab and a mobile lab. The stationary lab then can be used to implement a 'Fab4Fab programme' that enables the production of as many parts as possible locally to create new Fab Labs in the country. The mobile Fab Lab can extend the learning and capacities of a stationary lab to remote areas as well as to a larger audience of users.

BOX 4 – FAB LABS: A BRIEF OVERIEW[95]

Initiated in 2001 by the MIT, a Fab Lab is a technical prototyping platform for innovation and invention, providing stimulus for local entrepreneurship. It is also used as a platform for project-based, hands-on STEM education. Thus the target beneficiaries include established companies, entrepreneurs and students at all levels of education. Each Fab Lab is also a part of a distribution network of laboratories for research and invention that spans 100 countries and 24 time zones. There are 1,750 Fab Labs around the world that share a common set of tools and processes for research and invention. The international Fab Lab network is facilitated by the Fab Foundation.

Fab Labs provide access to the environment, the skills, the materials and the advanced technology to allow anyone anywhere to make (almost) anything. This includes technology-enabled products generally perceived as limited to mass production.

They also offer a wide range of educational programmes for all age groups and professional digital fabrication services for various types of organizations. Commercial activities can also be prototyped and incubated in a Fab Lab, but they must not conflict with other uses, they should grow beyond rather than within the lab, and they are expected to benefit the inventors, labs and networks that contribute to their success.

93 For example, an innovation cluster pilot could be considered for the Navoi Region, which was identified as a 'Free Economic Zone for Innovative, High-Tech, Export-Oriented and Import-Substituting Industries' with the Decree No. UP-5719 https://lex.uz/ru/docs/4339938

94 SMART stands for specific, measurable, achievable, realistic and time-bound

95 https://fabfoundation.org

While there are pre-incubators/accelerators for potential entrepreneurs, technology incubators hosting newly established STI-based enterprises do not exist in Uzbekistan. To stimulate the creation of technology start-ups by university students, graduates and researchers/academics, and to provide incubation services to the graduates of pre-incubation/acceleration programmes, a technology incubator could be piloted in Tashkent. It could be located between the National University of Uzbekistan and Tashkent State Technical University. Both universities, which are among the oldest and largest higher education institutes in Uzbekistan, are in close proximity to each other, as well as to the CAT, and have a strong research base. A technology incubator to be formed following international good practices could encourage the setting up of STI-based enterprises by students and new graduates of both universities and could also host the beneficiaries of the CAT Science Accelerator. It could also stimulate the commercialization of research results by hosting and assisting academic spin-offs. The technology incubation model to be developed and implemented could then be transferred to other regions of the country in order to develop technology innovation poles and regional ecosystems.

Investing in the development of research infrastructure to develop and disseminate emerging technologies in the country is of strategic importance for the innovative development of Uzbekistan. As noted before, the Tashkent University of Information Technologies plays an important role in that respect but lacks the required research infrastructure. It is advisable to assist the university in establishing a new laboratory infrastructure for space communication technologies and a research infrastructure for the AI R&D centre, not only to conduct research in the field but also to develop young researchers through postgraduate programmes.

As an important element of the national STI system, strengthening the National Quality Infrastructure is essential for economic diversification and exports. Thus, this infrastructure could be enhanced by (a) strengthening the areas of technical regulations, compliance, conformity and accreditation; (b) creating laboratory facilities and equipment for metrology, calibration and testing; and (c) carrying out awareness-raising and capacity-development activities on the subject among the target groups. The stakeholders consulted are of the opinion that priority should be given to agro-food, considering the strategic importance of the sector for the country and the difficulties experienced by the producers in obtaining international certification.

In order to facilitate the commercialization of research results and the transfer of knowledge from RIs and universities to the economy and society in general, it is essential to establish a national Technology Transfer Office (TTO). A project to be designed and implemented for this purpose can include (a) the creation of an inventory of research results (produced not only by the RIs of the academy and universities, but also by start-ups and established companies) with commercialization potential within and outside the country; (b) consulting and capacity building for the establishment of the TTO (recruitment and training of staff, developing the business plan, operational manual, commercialization model, etc.); (c) procurement of the hardware and software needed for the TTO; (d) piloting the first commercialization processes; and (e) awareness raising among researchers on the importance and benefits of knowledge and technology transfer, and conducting research with commercialization potential. To create synergies and enlarge the impact, these efforts could be integrated with the World Bank project (Uzbekistan Science Commercialization Project (P170206)),[96] which is being designed with the MoID in this area. It would be necessary to simultaneously create technology transfer units in the universities/RIs, which employ sufficient numbers of qualified staff to act as an interface between the researchers and the national TTO, and coordinate the activities internally within their organizations.

96 http://documents.worldbank.org/curated/en/424141575923996232/pdf/Concept-Project-Information-Document-PID-Uzbekistan-Science-Commercialization-Project-P170206.pdf

5.4. CAPACITY BUILDING IN STI AND DEVELOPING STI HUMAN CAPITAL

Achieving progress and success in the above areas requires the development of skills and capacities in STI policy-making and implementation. As highlighted by the NIS stakeholders, there is a need to establish clear definitions for the concepts that concern STI policies (including those such as start-ups and innovation centres) and to create a common understanding of them among all actors of the system. Furthermore, measures are required to continuously invest in developing the skills and capacities of policy, project and programme design and implementation teams at the ministries and other agencies (including the management units of innovation infrastructures), both in Tashkent and in the regions, through training and advisory services, as well as via staff exchange and mobility schemes.

Capacity development is also needed for management teams and researchers in the RIs, universities and the private sector. In addition to formal training and advice, putting in place a voluntary mentorship scheme for the transfer of knowledge and experience between researchers and businesses about ideation, project design, proposal writing and project management, as well as a mobility programme at national, regional and international levels, will be instrumental in developing and enhancing skills.

The government is actively promoting STEM education and encouraging young people to take up careers in STI and entrepreneurship. Modernization of the whole education system, including TVET, in line with the international education standards and involvement in PISA in 2021, will make a significant contribution to these efforts. It is necessary to put in place additional measures to attract girls to STEM subjects and to increase the participation of women in higher education, research and STI-driven entrepreneurship, as well as increasing women's representation in decision-making positions and in leadership roles in business, politics, research and education, in order to allow Uzbekistan to exploit its potential for accelerated development.

6. STI SWOT analysis

An analysis of the STI-related strengths, weaknesses, opportunities and threats (SWOT) for Uzbekistan is presented below. The STI SWOT is based on the findings of the national workshop organized in Tashkent on 18 February 2020, using a participatory approach. It also draws on the findings from the information and data presented in the preceding sections.

Strengths	Weaknesses
• High-level leadership and strong commitment to STI and SDGs • Strong reform programmes to improve the business climate and economic diversification • Existence of main players of the STI system and ongoing efforts to enhance it • Existence of policy instruments and infrastructures to stimulate STI • Ongoing work to improve the legal framework for STI • Favourable contextual factors for STI (historical background, cultural and social norms, notably liberal gender policy, multiculturalism, openness, tolerance, flexibility and mobility) • Internationally recognized scientific research potential • Ongoing and increased investment in research and innovation infrastructures • Strong scientific community and the Academy of Sciences • Existence of basic factors to attract human capital and investments for STI (tax advantages, human resources, cancellation of visa requirements, government guarantee for investments and initiator of reforms, etc.)	• Need to design and implement a holistic national STI policy • Need to improve the STI governance system by putting in place the necessary elements and redefining roles and responsibilities • Need to create a balanced policy mix by designing direct and indirect STI policy instruments • Need to improve policy and programme monitoring and evaluation practices • Need to develop human capital for STI • Need for building skills and capabilities of the NIS actors about STI policy, programme and project design and implementation • Need to increase awareness and create a common understanding of STI among all stakeholders • Need to address regional development challenges • Need to modernize educational programmes • Need to improve the national ICT infrastructure • Low number of population with higher education degrees • Low attractiveness of science for the new generations and need to popularize science • Need to further improve the RIs and universities
Opportunities	**Threats**
• Political stability and national security • Rich natural resources, raw materials and cultural heritage • Availability and accessibility of emerging technologies • Addressing regional development challenges through smart specialization strategies • High potential for renewable energy production • Young and growing population • Access to international knowledge and information and increased international cooperation in the field of STI • Potential to attract foreign R&D investment • Favourable geographical and geopolitical location • Mobilizing skilled human capital available in diaspora	• Weak awareness of innovation and low investment in STI by the private sector • Climate change and natural disasters • Regional disparities and development challenges in regions • Risk of brain drain

7. Conclusions and recommendations

7.1. CONCLUSIONS

Uzbekistan is highly committed to STI as a vital tool for achieving socio-economic development and has determined to attain the ambitious goals within one decade. As discussed in the previous sections, there is an intensive ongoing effort to set up the NIS, encourage R&D and innovation, and the commercialization of research results. Taking into account the developments and achievements of the last three years, and considering the opportunities and needs analysed in Section 5, the following recommendations are proposed to the government to support the process of transformation into an innovation-driven economy.

7.2. RECOMMENDATIONS

7.2.1. STI policy, system and governance

I. Empower the Republican Council on Science and Technology to play an advisory and oversight role for the formulation and implementation of STI policies, establishment of multi-stakeholder dialogue, design of a coherent STI policy mix, and integration of STI in other policy areas.

II. Appoint the MoID as the secretariat organization of the Council for the effective management of the STI policy cycle from design to evaluation, ensuring the transparency and accountability of public support for STI, and eliminating any potential conflict of interest and overlaps in the system.

III. Design a fully-fledged STI policy for the next ten years with the active involvement of the NIS stakeholders (universities, companies, R&D centres, civil society, innovation infrastructures, etc.).

IV. Create two multi-disciplinary programme implementation institutions in the form of a national innovation agency[97] and a national science agency[98] for the design and implementation of innovation and research policy instruments, respectively.

V. Redistribute the roles among the NIS stakeholders involved in the implementation of policies, strategies and measures for innovative development, taking into account principles such as segregation of duties, transparency and coordination effectiveness.

VI. Establish and maintain a balanced policy mix, and evaluate and improve the existing STI instruments and STI infrastructures (RIs, technoparks/IT parks, innovation centres, etc.) to achieve greater and sustainable impact, and eliminate duplication, if any.

VII. Ensure that policy instruments are not confined to R&D performers or technology-based enterprises, but also target SMEs and grass-roots innovators.

VIII. Diversify the funding mechanisms to finance STI activities of different target groups.

IX. Improve legislation and simplify administrative processes of public interventions for STI.

X. Ensure that a monitoring and evaluation system for policies and policy measures becomes an integral part of the STI policy cycle, following international good practices.

XI. Introduce measures to create dynamic local and regional innovation ecosystems and integrate them with the national and global innovation systems by supporting partnerships, and collaborative and inter-disciplinary projects.

XII. Ensure that regional innovation councils are created, and smart specialization strategies are developed and implemented by the regions.

XIII. Establish a single window to make information and guidance available for research performers, entrepreneurs and the private sector about policies and support measures for STI.

97 Examples of agencies which design and implement public support programmes to promote innovation can be found in a large number of developed and developing countries, e.g. VINNOVA in Sweden, Innovate UK, Innosuisse in Switzerland, Enterprise Estonia and MITA in Lithuania.

98 Some examples of national science agencies are NSF in the USA, ARC in Australia, ANR in France, JST in Japan and SFI in Ireland.

XIV. Use public procurement to encourage R&D and innovation in the private sector, and collaboration with research performers to design and implement innovation-based solutions.

XV. Encourage the creation of innovation intermediaries and service providers to facilitate the creation, diffusion and use of knowledge, technology and innovation.

XVI. Strengthen the RIs, particularly those of the Academy of Sciences, by implementing a comprehensive reform programme.

XVII. Develop procedures, processes and criteria for the selection, implementation, monitoring and evaluation and scaling up of pilot STI initiatives.

XVIII. Improve the coordination of public sector innovation projects implemented by different ministries and public agencies.

7.2.2. STI policy mix

I. Establish good practices in programme design for all policy instruments (i.e. develop problem tree, theory of change indicators and SMART targets, monitoring and evaluation framework, process descriptions and rules and regulations, and put in place a complete set of programme documents).

II. Ensure that policy instruments put a clear and specific focus on social and inclusive innovation, and define women and youth as the primary beneficiaries of the measures.

III. Introduce a brain gain programme by creating a diaspora network of Uzbek researchers, entrepreneurs and other highly skilled human resources living and working in other countries. Encourage them to actively participate in the STI-driven transformation through different channels, such as direct investment, outsourcing, providing knowledge and mentoring, and offering finance by participating in angel networks, etc.

IV. Design and implement awareness-raising campaigns tailored to different target groups on STI-related areas including, but not limited to, the importance of quality, standards and certification. Promote science journalism and cooperate with journalists, opinion leaders and influencers for better communication of STI. Identify and promote success stories of individuals with creativity, innovation and entrepreneurship mindset and achievements.

V. Introduce policy measures to encourage creative thinking, innovation and entrepreneurship culture in all regions and sectors, and among all target groups.

VI. Develop and launch a linkage programme to ensure transfer of knowledge and technology from foreign investors and projects to local SMEs, RIs and start-ups.

VII. Design and implement a sectoral STI programme aiming to support R&D and innovation projects, particularly in health, agriculture and education.

VIII. Encourage the development of innovation clusters in regions as well as in the research hot spots of the capital.

IX. Diversify funding mechanisms by providing both government support in the form of soft loans and grants, and developing private modes of finance.

7.2.3. STI infrastructure

I. Establish Fab Labs to benefit from emerging technologies in the innovation process, and to provide stimulus for local entrepreneurship as well as for STEM education.

II. Establish technology incubators hosting newly established STI-based enterprises. Consider creating the first one at a location between the National University of Uzbekistan and Tashkent State Technical University.

III. Ensure that new research and innovation infrastructures are established within close proximity of the universities and research centres, to be able to develop local and regional innovation ecosystems.

IV. Establish a new laboratory infrastructure for space communication technologies and the research infrastructure for the AI R&D centre at the Tashkent University of Information Technologies.

V. Create a dynamic network and collaboration between all innovation infrastructures (Fab Labs, accelerators, incubators, technoparks, RIs, etc.) and encourage them to collaborate, learn from good practices and increase the impact of their activities.

VI. Enhance the national quality, metrology and standardization infrastructure, and offer internationally recognized certification in all sectors.

VII. Clearly define the mandates of universities and colleges as education, research and 'third task', i.e. knowledge transfer to society and commercialization of research results for the economy.

VIII. Create a national Technology Transfer Office (TTO) to identify and commercialize research results from universities/colleges and research centres, transfer knowledge to society and to initiate contract and joint R&D activities within the country.

IX. Establish technology transfer units in the universities/colleges and RIs; ensure that they employ a sufficient number of qualified staff to act as an interface between the researchers and the national TTO, and to coordinate activities internally within their organizations.

X. Ensure that the national TTO creates an inventory of STI capabilities and infrastructures (laboratories, equipment, devices, etc.) and make it available to all NIS stakeholders, including the private sector.

XI. Encourage the creation of non-governmental organizations, cluster coordination units and private companies specializing in research and innovation management to act as intermediaries between the research community, private sector and the government, as well as service providers to the research performers and enterprises engaged in R&D and innovation activities.

7.2.4. Capacity building and human capital

I. Establish clear definitions for the concepts that concern STI policies (including those such as start-up and innovation centre) and create a common understanding about them among all actors of the system.

II. Develop measures to continuously invest in skills and capacity building for teams responsible for policy, project and programme design and implementation at the ministries and other agencies (including the management units of innovation infrastructures).

III. Develop capacities and skills of management teams and researchers in the RIs, HEIs and the private sector on project design, proposal writing and project management.

IV. Introduce special measures to attract girls to STEM subjects to increase the participation of women in research, higher education and STI-driven entrepreneurship. Increase women's representation in decision-making positions as well as in leadership roles in business, politics, research and education.

V. Implement awareness campaigns and policy measures to motivate students in all regions towards STEM careers from an early age. Engage students in meaningful real-life problem-solving situations through projects and programmes that promote creativity, innovation and entrepreneurship throughout the educational lifecycle.

VI. Promote STI-based careers and employability. Introduce mobility initiatives to support the placement of STEM teachers and university students in enterprises within the country and the region.

VII. Expand science education opportunities through science museums, centres, festivals and competitions for citizens of all ages and in all regions.

VIII. Ensure that the promotion/performance regulations for researchers put less emphasis on publications, and promote instead patenting, results-oriented research and research commercialization.

IX. Increase awareness of IPR protection, and design and implement measures to encourage patenting among firms and R&D centres and universities; develop the capabilities of patent attorneys.

X. Introduce researcher and R&D staff mobility at national, regional and international levels.

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Glossary

Evaluation

The systematic and objective assessment of an ongoing or completed project, programme or policy, its design, implementation and results. The aim is to determine the relevance and fulfilment of objectives, development efficiency, effectiveness, impact and sustainability. An evaluation should provide information that is credible and useful, enabling the incorporation of lessons learned into the decision-making process of both recipients and donors. 'Evaluation' also refers to the process of determining the worth or significance of an activity, policy or programme. (OECD definition)

Ex-ante evaluation

An evaluation that is performed before implementation of a development intervention. (OECD definition)

Ex-post evaluation

Evaluation of a development intervention after it has been completed. It may be undertaken directly after or long after completion. The intention is to identify the factors of success or failure, to assess the sustainability of results and impacts, and to draw conclusions that may inform other interventions. (OECD definition)

External evaluation

The evaluation of a development intervention conducted by entities and/or individuals outside the donor and implementing organizations. (OECD definition)

Gender parity

Purely a numerical concept; for R&D statistics, gender parity is reached when women represent between 45% and 55% of the total number of researchers.

Reaching gender parity in education implies that the same proportion of boys and girls – relative to their respective age groups – would enter the education system and participate in its different cycles.

Gross domestic product

The sum of gross value added by all resident producers in the economy, including distributive trades and transport, plus any product taxes and minus any subsidies not included in the value of the products.

Inclusive innovation

Any innovation that helps expand affordable access to quality products and services that create and increase livelihood opportunities for excluded populations. (World Bank definition)

Innovation

Deriving the benefits from a new or significantly improved product (good or service), or process (such as a new marketing method), or a new organizational method (such as in business practices, workplace organization or external relations).

A key point to differentiate innovation from improvement is that innovation derives significantly (as opposed to incrementally) more impact (economic, social and environmental) from existing products, processes and services, or from a combination of proven and new science and technology, to develop new products, processes or services. Innovation should be understood as something new to a local context. It may also include adapting imported technologies to local conditions.

Social innovation can similarly be defined with the addition that it simultaneously meets social needs while creating new social relationships or collaborations. In other words, they are innovations that change society and enhance its capacity to act.

An important type of innovation that predominantly concerns the least developed and STI lagging countries is *inclusive innovation*. It refers to any innovation that helps expand affordable access to quality products and services that create and increase livelihood opportunities for excluded populations – on a sustainable basis and with significant outreach. This type of innovation seeks to expand access to essential goods and services, thereby improving quality of life and enhancing economic empowerment through knowledge creation, acquisition, adaption, absorption, and deployment efforts targeted directly at the needs of excluded populations, primarily at the 'base of the pyramid' – those earning less than two dollars a day.[99]

Innovation policy

A set of policy instruments and appropriate institutions that assist in the local adoption of technologies and the introduction of new products and services to the market.

This may include adapting imported technologies to local conditions.

Innovation policy can be characterized in various ways, such as by distinguishing between 'supply-side' and 'demand-side' policy, or between 'mission-oriented' and 'diffusion-oriented' policy. Policy instruments include financial instruments (e.g. R&D tax credits, export incentives, soft loans, etc.) and regulatory instruments such as laws and binding regulations (e.g. the use of safety equipment for children in cars). Innovation policy encompasses many types of innovation. Innovation may be characterized *inter alia* by: the type of innovation – technological (product and process) or non-technological (organizational and marketing); the mode of innovation – novel innovator (strategic and intermittent), technology modifier and technology adopters; and the socio-economic impact – incremental, disruptive or radical.

Intellectual property (IP)

Refers to creations of the mind: inventions, literary and artistic works, symbols, names, images and designs used in commerce. IP is divided into two categories: industrial property, which includes patents, utility models, trademarks, industrial designs and geographical indications of source; and copyright, which includes literary and artistic works such as novels, poems and plays, films, musical works, and artistic works such as drawings, paintings, photographs, sculptures and architectural designs. Rights related to copyright include those of performing artists in their

99 World Bank (2013)

performances, producers of phonograms in their recordings and those of broadcasters in their radio and television programmes.

Mid-term evaluation

Evaluation performed towards the middle of the period of implementation of the intervention. (OECD definition)

Monitoring

A continuing function that uses systematic collection of data on specified indicators to provide management and the main stakeholders of an ongoing development intervention with indications of the extent of progress and achievement of objectives and progress in the use of allocated funds. (OECD definition)

National innovation systems

Refers to the complex and interactive web of knowledge flows and relationships between industry, government and academia and making them work systematically to sustain innovation and science and technology development efforts. The innovative performance of a country depends to a large extent on how these NIS actors relate to each other as elements of collective systems of knowledge creation and use, as well as the technologies they use. (OECD definition)

Patent

A set of exclusive rights granted by law to applicants for inventions that are new, non-obvious and commercially applicable. It is valid for a limited period of time (generally 20 years), during which patent holders can commercially exploit their inventions on an exclusive basis. In return, applicants are obliged to disclose their inventions to the public in a manner that enables others, skilled in the art, to replicate the invention. The patent system is designed to encourage innovation by providing innovators with time-limited exclusive legal rights, thus enabling innovators to appropriate a return on their innovative activity.

Policy mix

Refers to the combination of direct and indirect programmes through which financial and non-financial support is provided to target groups.

Programme, policy instrument and policy measure

The terms used interchangeably to describe an intervention, which is multi-annual and has a pre-defined budget, specific target group and objectives, implementation rules and regulations, as well as a monitoring and evaluation framework.

Research and experimental development (R&D)

Covers basic research, applied research and experimental development, both formal R&D in R&D units and informal or occasional R&D.

Researchers

Professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems, as well as in the management of the projects concerned.

Science

The systematic study of the physical or material world (natural science) and of society (social science) that generates, or creates, knowledge from which data and information is drawn.

Science policy

Relates to those policies needed to: promote scientific research, determine and select scientific objectives and goals consistent with national plans or strategies, exercise judgment in fixing norms to govern the ways and means by which science is developed, transferred and applied; gather, organize and deploy resources required to pursue the selective objectives; and monitor and evaluate the results obtained from applying the policy.

STI

An integrated life cycle where science leads to new technologies from which innovations develop. Innovative ways of doing things can change and influence the development of science and how and what technologies are brought forth which, in turn, also influence the innovation process.

STI policy cycle

Refers to the process through which STI policy-makers define the challenges and needs, identify policy alternatives, select the policy options that yield the greatest impact, implement selected policy options, and monitor and evaluate the results and impacts.

Technology

The application of scientific knowledge to develop techniques to produce a product and/or deliver a service or as the application of scientific knowledge for practical ends.

Technology policy

The fundamental premise of technological policies is that it is possible for governments to implement public policies to improve social welfare by influencing the rate and direction of technological change.

Annex: The methodological framework for this series

UNESCO's Country Profiles in Science, Technology and Innovation Policy series of reports is published within the Global Observatory of Science, Technology and Innovation Policy Instruments (GO→SPIN), a programme run by UNESCO's Division of Science Policy and Capacity-Building.

The aim of this series is to generate reliable, relevant information about the different landscapes of science, technology and innovation (STI) policies around the world. The published information is based on desktop research and surveys, combined with government reports and statistical data from the UNESCO Institute for Statistics and other international sources.

The country profile represents a comprehensive study of the STI policies, which include:

1. A description of the political, economic, social, cultural and educational contextual factors.
2. An analysis of the STI policies, including those research and innovation policies implemented in other sectors, such as the agricultural, energy, health, industrial and mining sectors.
3. A study of R&D and innovation indicators.
4. A scientometric analysis of scientific publications, patents, tradmarks and utility models.
5. A historical description of the long-term evolution of STI policies and institutions.
6. A description of the STI policy cycle.
7. An analysis of the STI organization.
8. A description of the STI legal framework, including acts, bills, regulations and international agreements on STI issues.
9. A description of the STI operational policy instruments in place.
10. A SWOT analysis of the country's research and innovation landscape.
11. A summary of recommendations.

UNESCO'S APPROACH

The strategy of the programme is four-fold:

- **Capacity-building:** training high-ranking national officials in the design, implementation and evaluation of a variety of STI policy instruments at national and regional levels;
- **Standard-setter:** providing a practice for surveys on STI policies and operational policy instruments;
- **Data collection:** distribution of surveys, prioritizing Africa, Arab States, Asia-Pacific and Latin American and the Caribbean;
- **GO→SPIN platform:** online, open access platform for decision-makers, knowledge-brokers, specialists and general public, with a complete set of information on STI policies.

The online platform provides an innovative cluster of databases equipped with powerful graphic and analytical tools. The platform is developed for political leaders, planners, directors and administrators of STI in government, parliament, universities, research institutions, productive enterprises concerned with innovation, international organizations working for development, research personnel and specialists whose field of study embraces STI policies.

The GO→SPIN survey and the information generated are primarily intended for the use of specialists and governmental bodies responsible for national STI policies. It is their function to analyse the results of the survey and draw appropriate conclusions when they are required to prepare decisions by political bodies in the field of science, engineering, technology and innovation. The survey is also of interest to national bureaux of statistics and international organizations for promoting scientific and technological cooperation among their member states. Collectively, these users are:

- The national developing planning agencies, more particularly the government bodies responsible for formulating and co-ordinating national STI policies and other national bodies involved in the application of science and technology (S&T) to sustainable development;
- Parliamentary groups, especially those concerned with STI policies;
- STI information brokers, consulting groups and advisory bodies;
- Teaching and research departments engaged in STI policy studies;
- The governing bodies of R&D institutes and S&T services;
- The boards of management of productive enterprises heavily reliant on R&D or engaged in the transfer of technology and innovation;
- International governmental and non-governmental organizations concerned with STI and its application to sustainable development;
- Other more peripheral users, such as university departments of political science, economics and social sciences and national and international documentation and information services;
- The mass media.

At individual level, the main groupings are:

- **Decision-makers:** those responsible for national STI policies and the management of R&D (ministries of R&D or S&T, directors of bodies responsible for formulating national STI policies, directors of R&D institutes, heads of productive enterprises heavily reliant on R&D, etc.).
- **Intermediate users:** those who serve as the link between decision makers referred to above and researchers in STI policy; their function is to prepare decisions by the former using theories and methods put forward by the latter. This category is made up of experts, consultants, advisers, liaison officers, the staff of ministerial offices and of parliamentary committees, etc., and they usually require rapid access to factual data.
- **Researchers in STI policies:** those who develop the theories and methods on which STI policy is based (researchers in the areas of philosophy, history, sociology and economics of science, engineering and innovation), in the transfer of technology and in the management of R&D.
- **The general public:** by making STI information more accessible, UNESCO's approach introduces a new dimension to the democratization of STI.

THE METHODOLOGICAL FRAMEWORK

Science, technology and innovation (STI) are increasingly important for socio-economic and sustainable development. During the past 60 years, both developed and developing countries have recognized this fact by increasing the number of STI government bodies, establishing new STI legal frameworks and implementing a diverse set of new STI policy instruments. This has driven investment in scientific research, technological development and innovation, led to an increase in the number of scientists and engineers and fostered exponential growth in the number of new scientific articles and patents worldwide (UNESCO, 2010).

The information economy is one of the key concepts invented to explain structural changes to the modern economy (Godin, 2008). The infrastructure to manage STI information has been largely considered the core resource of national competitiveness in research and innovation (Neelameghan and Tocatlian, 1985). With the globalization of STI information infrastructure has come a need to implement comprehensive strategies to connect, share and trade both domestic and foreign information at the national level (Lee and Kim, 2009).

The formulation of adequate STI policies is critical to tackling contemporary challenges that include: mitigating the consequences of global climate change; exploring new energy sources; generating innovation to foster social inclusion; promoting the sustainable management and conservation of freshwater, terrestrial resources and biodiversity; disaster resilience; and fostering the eradication of extreme poverty and hunger. These policies also need to be designed to achieve the Sustainable Development Goals.

Over the past five decades, operational definitions have been elaborated within the framework of multilateral organizations to measure R&D and the broader concept of S&T. Statistical techniques have been developed to estimate private and public resources invested in these areas. For the former, the OECD has laid down a methodological framework in the *Frascati Manual,* the latest edition of which was published in 2015. For the latter, the Member States of UNESCO have adopted the *Recommendations concerning the International Standardisation of Statistics on Science and Technology* (UNESCO, 1978; 1982; 1984*a*; 1984*b*). Methodologies for generating data about R&D investment and human resources have been constantly upgraded and extended.

During the first African Ministerial Conference on Science and Technology (AMCOST),[100] in 2003, countries committed themselves to developing and adopting a common set of STI indicators. The New Partnership for African Development (NEPAD) established the African Science, Technology and Innovation Indicators Initiative (ASTII) with the objective of building Africa's capacity to develop and use STI indicators. More specifically, NEPAD aims to: (a) develop and promote the adoption of internationally compatible STI indicators; (b) build human and institutional capacities for STI indicators and related surveys; (c) enable African countries to participate in international programmes on STI indicators; and (d) inform African countries on the state of STI in Africa. The first *African Innovation Outlook* was published in 2010,[101] while the second volume was published in 2014. The methodology employed – that suggested by ASTII officials – follows the recommendations of the *Frascati Manual* for R&D indicators and the *Oslo Manual*, 3rd edition (OECD, 2005) for innovation indicators.

In 2009, the UNESCO Institute for Statistics organized an Expert Meeting on Measuring R&D in Developing Countries, in Windhoek (Namibia), with the aim of working towards a global standardization of STI statistics, including those which are not taken into account in the *Frascati Manual* (UNESCO Institute for Statistics, 2010; see Box 5) . During the meeting, the experts identified the difficulties and challenges faced by the majority of developing countries, which were not explicitly addressed in the *Frascati Manual*.

100 The final declaration of the AMCOST meeting in 2012 recommended coordination between the African Observatory on STI (AOSTI), ASTII and UNESCO's GO→SPIN.

101 AU-NEPAD, 2010

BOX 5 – MEASURING R&D: CHALLENGES FACED BY DEVELOPING COUNTRIES

The methodology for measuring R&D is detailed in the OECD *Frascati Manual*, which has been in use for more than 50 years. A revised edition was published in 2015. Despite the manual's longevity, developing countries still face problems when trying to apply its standards to measuring the situation in their particular country.

The UNESCO Institute for Statistics conducts a biennial data collection of R&D statistics and produces a methodology tailored to the needs of developing countries; it also holds training workshops and builds capacity through other means in developing countries. AU-NEPAD, 2010

In 2014, the UNESCO Institute for Statistics published a *Guide to Conducting an R&D Survey: For Countries starting to Measure R&D*.[102] This guide presents the relevant R&D indicators, discusses the main issues facing each of the major sectors of performance, provides a simple project management template and proposes generic model questionnaires for the government, higher education, business and private non-profit sectors which countries can use and adapt to suit their needs.

In 2010, the UNESCO Institute for Statistics produced a technical paper on *Measuring R&D: Challenges faced by Developing Countries*. The OECD Working Party of National Experts on Science and Technology Indicators subsequently suggested that the paper serve as the basis for an annex to the *Frascati Manual: Proposed Standard Practice for Surveys of Research and Experimental Development (6th edition)*. This annex was adopted as an online adjunct to the OECD *Frascati Manual* in March 2012 and added to the 2015 version.

Measuring R&D: Challenges faced by Developing Countries provides guidance on a number of challenges that are relevant to developing countries and which may not be elaborated on clearly enough in the *Frascati Manual*. The following situations are addressed in the document, among others:

- Despite the increasing presence of developing countries in global R&D, there is still a marked lack of demand for science, technology and innovation (STI) indicators from policy-makers in developing countries. Even where the demand does exist, there are often significant problems with compiling the data due to a lack of coordination at the national level, a lack of cooperation by research institutions, universities and businesses, and a generally weak statistical system in the country.
- R&D used to be largely funded by the government but new sources of funds are emerging. Foundations, scientific associations, NGOs and particularly foreign organizations already play an important role. In addition, the contribution of private business is becoming more important and gaining more recognition in a wider range of developing countries. Many of these new sources of funding go directly to individuals and groups rather than to institutions and therefore remain unaccounted for, including for statistical purposes.
- Although the *Frascati Manual* recommends the collection of primary data through direct surveys, the use of secondary data from national budgets and budgetary records of public R&D performing units has been a widely adopted practice to obtain a rough estimate of gross expenditure on R&D (GERD). However, there is often a discrepancy between voted and allocated budgets. Furthermore, national research systems have a limited absorption capacity, which may leave funds unused in central accounts instead of being transferred to institutions performing R&D. Moreover, care needs to be taken to ensure that such transfers are not 'double counted' as expenditure of both the funding body and the institution performing R&D.
- The definitions used by finance ministries and other government institutions to establish S&T budgets may be *ad hoc* and fail to distinguish between broad S&T and narrower R&D activities. Furthermore, many institutions (universities in particular) do not compile a separate R&D budget, especially where research is a low institutional priority.

102 UIS, 2014

- R&D components in the national budget, especially capital expenditure, can be difficult to identify and may be aggregated under different headings. In addition, when R&D activities stretch over more than one financial year, it may not be easy to estimate the amount of resources used each year. For example, work done to develop land and buildings used for research in a given year should be clearly earmarked and not recorded in subsequent years.
- A concentration of innovation activities by sector or in a small set of institutes may lead to volatility and inconsistencies in statistics. There is generally lower emphasis on R&D in the business sector, in part due to reduced competitive pressure in local markets.
- In the higher education sector, the increasing number of private universities makes it useful to distinguish between public and private higher education and to further break up private higher education into government-dependent and independent private institutions. Further disaggregation into private-for-profit and private-not-for-profit higher education institutions should also be considered to track where most research is carried out.
- Surveys that cover all R&D performers should in principle all report for the same period. This is difficult to achieve since, in many countries, higher education institutions and businesses do not necessarily report on the same period – the business sector's calendar tends to be the most problematic. Also, not all countries follow the same calendar. As a solution, the recommendation that R&D performers report on the financial year closest to the survey period may have to suffice.
- Information systems in government and higher education are often not set up to enable the extraction of data on R&D personnel and expenditure. Thus, accurate information on financial expenditure only becomes available a long time after completion of an activity. Unfortunately, ad hoc IT solutions to address these issues may also lead to errors and inconsistencies.
- The collection of data in full-time equivalents (FTE) for researchers provides useful information on the true volume of human resources devoted to R&D. This information is also essential for estimating R&D labour costs. Tallying the number of researchers in a given country presents further challenges. In some developing countries, salaried researchers may not have research budgets or unpaid researchers may undertake research. In other scenarios, academic staff may hold part-time contracts at more than one university. Even if academic staff have contracts that specify the amount of time to be spent on conducting research, it is difficult to enforce, especially where there is a lack of resources. Estimating the time spent on research and hence the calculation of the FTE for research staff – particularly in the higher education sector – is fraught with difficulties. This directly impacts the calculation of R&D expenditure.

A number of special types of activity warrant attention when measuring R&D, as they are on the border of what is considered R&D. Three examples follow from the technical paper:

- In the case of traditional knowledge, it is important to set boundaries. Activities which establish an interface between traditional knowledge and R&D are considered R&D. However, the storage and communication of traditional knowledge in traditional ways is excluded.
- Clinical trials are an area of growth in some developing countries. Identifying research personnel in the extended clinical trials value chain may be difficult, as their involvement is occasional and harbours a risk of double counting (i.e. as personnel in the trial and as academic staff).
- Reverse engineering is important in many developing countries. However, this generally falls outside the scope of R&D. Only if reverse engineering is carried out within the framework of an R&D project to develop a new (and different) product, should it be considered R&D.

STI statistical systems are often weak in developing countries. To help strengthen these systems, the paper recommends that countries institutionalize R&D statistics, establish registers of R&D performers and document survey procedures and estimations.

Countries interested in embarking on R&D measurement are encouraged to contact the UNESCO Institute for Statistics.

The availability of input and output R&D indicators alone does not suffice to evaluate STI policies. Much more important than the particular value of one specific indicator at a given time is the long-term rate of change that long temporal series of indicators show (Lemarchand, 2010, pp. 27–28). For that reason, long-term temporal series of indicators are necessary to analyse the impact of specific public policies. Improving the reliability of this analysis requires new ways of standardizing information about public policies and the policy instruments designed to implement them. Owing to the complexity of these issues, the 'science of science policy' has emerged in recent years as a discipline where new analytic paradigms can be tested.

Better ways of measuring evidence-based policies

STI policy debates are not yet dominated by a thoughtful, evidence-based analysis of the likely merits of different investment options and policy decisions. The latter are strongly influenced by past practice or data trends that may be out of date (Husbands Fealing et al., 2011). The evolution of new policies has been accompanied by more difficult challenges related to planning and evaluating these policies (see Box 6); this indicates a need to improve the theoretical frameworks for policy formulation (Steinmueller, 2010).

Unfortunately, a number of factors prevent countries from reaching most of the objectives established by their own development plans: the lack of reliable information on STI national potentialities; difficulties in coordinating the various STI stakeholders; an absence of mechanisms for promoting a strong interaction between the supply and demand sectors in STI; and the absence of any explicit industrialization policy promoting endogenous innovation.

BOX 6 – THE POLICY-MAKING CYCLE

A stylized presentation of the policy-making cycle typically involves five stages:

- *Agenda-setting*: refers to the process by which problems related to STI and the linkages between STI and both society and the economy come to the government's attention;
- *Policy formulation*: refers to the process by which STI policy options are formulated by the government;
- *Decision-making*: refers to the process by which governments adopt a particular course of action or non-action;
- *Policy implementation*: refers to the process by which governments put STI policies into effect; and
- *Policy evaluation*: refers to the process by which the results of STI policies are monitored by both the state and societal actors. The result may be a re-conceptualization of policy problems and solutions, in which the effectiveness, efficiency and continuing appropriateness of policies and policy instruments are assessed and the results fed back into another round of agenda-setting.

Responsible and accountable STI governance entails developing capabilities at each of these five stages.

These difficulties mostly appear in small economies. For example, Flanagan et al. (2011) have explored the ways in which innovation policy studies treat actors, instruments, institutions and interactions, in order to arrive at a more useful conceptualization of the policy mix for innovation. They stress the need for a genuinely dynamic view of policy formulation and policy interaction. They conclude that 'despite the importance attached to "strategic policy intelligence" in recent innovation policy analysis, little empirical attention has been devoted to actual processes of policy learning.' In developing and exploiting technological opportunities, institutional competencies – namely, the governance of STI decision-making bodies – are just as important as the STI incentive instruments they promote (Pavitt, 1996). Path dependency emerges, as the cost of institutional changes to STI is often higher than that of accommodating new instruments and

policies in existing structures (van der Meulen, 1998). For this reason, the design, analysis and monitoring of any national STI policy will strongly depend on the adequate mapping of: the structure of the STI governing bodies; the STI national legal framework; and of the implicit and explicit operational STI policy instruments that are implemented (Herrera, 1971, 1972; Sagasti and Aráoz, 1976).

WHY TALK ABOUT STI POLICIES?

The term 'science policy' was coined following the publication in 1945 of Vannevar Bush's seminal article *Science – the Endless Frontier*, which laid the foundations for the first social contract for science. By 1950, UNESCO had initiated the first systematic studies on science policies in a dozen developed countries. Originally, this term referred to public policies related to scientific and technological research, experimental development, scientific and technological services and innovation. *Science policy* as a discipline evolved over the coming decades. Today, it is possible to distinguish specific operational policy instruments according to the different needs established by science policies, engineering policies, technology policies and innovation policies. As these four distinct types of public policy require different skills, major universities around the world have recently introduced specific postgraduate programmes targeting each of the four types of policy:

Science policy: relates to those policies needed to: promote scientific research, determine and select scientific objectives and goals consistent with national plans or strategies, exercise judgment in fixing norms to govern the ways and means by which science is developed, transferred and applied; gather, organize and deploy resources required to pursue the selective objectives; and monitor and evaluate the results obtained from applying the policy. The following are therefore among the most important questions dealt with by policy-makers in the field of science policy: (a) establishing and strengthening government structures and mechanisms for planning, budgeting, coordinating, managing and promoting scientific research; (b) gathering, processing and analysing basic data concerning the national scientific potential, including data on ongoing research, monitoring national scientific development and ensuring the smooth growth of the institutional infrastructure for scientific research; (c) maintaining a proper balance between the various types of research (fundamental, applied, experimental development), supporting the development of a creative national scientific community and setting standards for the status of scientific researchers in conformity with their responsibilities and rights; (d) optimizing human, financial, institutional and informational resources to achieve the objectives established by the national STI policy; (e) assessing and promoting productivity, relevance, quality effectiveness of national research and scientific and technological services in various sectors of performance (higher education, government institutions, business enterprise, private non-profit) and removing organizational and managerial difficulties encountered in the execution of scientific research; (f) initiating appropriate legislative action in relation to the impact on the individual, society as a whole or the natural environment of the application of discoveries and inventions; evaluating the economic profitability and social utility (or harmful effects) of the said discoveries and inventions. Although the aforementioned list is not exhaustive, it indicates the key areas for which government policy-makers are primarily responsible. Each individual issue requires the design of a particular operational policy instrument.

Engineering policy: the role of engineers in public policy can be seen as a two-fold endeavour: (1) to help create public policy related to the utilization of technology to solve public problems as well as monitor and ensure compliance with such policies; and (2) to use engineering knowledge to assist in the construction of policy directives to help solve social problems. In many cases, the development and implementation of such regulations and laws requires both a technical understanding of the functioning of these artefacts and an understanding of how this technology interacts with social and natural systems and would benefit from the involvement of a technical expert. The issues addressed by engineering policies are vast and global in nature and include water conservation, energy, transportation, communication, food production, habitat protection, disaster risk reduction, technology assessment and the deterioration of infrastructure systems.

These issues need to be addressed while respecting the rights and meeting the needs and desires of a growing world population.[103]

Technology policy: the fundamental premise of technological policies is that it is possible for governments to implement public policies to improve social welfare by influencing the rate and direction of technological change. The conventional entry point for economic analysis is to identify the conditions needed for such influence to be superior to the outcome of ordinary market competition. These conditions, in turn, direct further examination of the feasibility and methods for such intervention, including the question of whether government intervention is necessary to improve social welfare. Succinctly stated, government intervention would be necessary if profit-seeking actors underperformed or performed poorly in producing or exchanging technological knowledge from the perspective of social welfare.

Innovation policy: innovation policy can be characterized in various ways, such as by distinguishing between 'supply-side' and 'demand-side' policy, or between 'mission-oriented' and 'diffusion-oriented' policy. Policy instruments include financial instruments (e.g. R&D tax credits, export incentives, soft loans, etc.) and regulatory instruments such as laws and binding regulations (e.g. the use of safety equipment for children in cars). Innovation policy encompasses many types of innovation. Innovation may be characterized, *inter alia*, by: the type of innovation – technological (product and process) or non-technological (organizational and marketing); the mode of innovation – novel innovator (strategic and intermittent), technology modifier and technology adopters; and the socio-economic impact – incremental, disruptive or radical. The effectiveness of innovation policies requires a sufficiently stable framework, institutions and policies. Stability and predictability are particularly important for risky activities with a long time horizon such as R&D and innovation. Excessive instability may inhibit innovation by increasing uncertainty for innovators. It may lessen the effectiveness of policy instruments by weakening the incentives they provide. In addition, it reduces opportunities for learning and developing evidence-based policy practices. Whereas there are manifold sources of unwarranted discontinuities, political instability and fiscal problems – often related to policy cycles – are a common cause. In an increasingly complex innovation landscape, developing effective governance requires better coordination at, and among, the local, regional, national and international levels.

STI projects normally occur within a larger temporal framework administered by an organization or a government policy-making body. The early stages of a new STI policy usually appear as successive expansions of the group of agents and stakeholders whose endorsement is needed to launch the initiative, whereas the latter stages focus on programme management, with feedback as to its success or failure at the policy level (Marburger III, 2011). Consequently, in order to provide an accurate landscape of the STI policies and policy instruments in a specific national context, it is imperative to understand the long-term evolution of the STI organizational chart, STI infrastructure and legal framework (i.e. explicit policies), as well as the type of funding mechanisms implemented. The latter dimensions must be contrasted with detailed analyses of the long-term behaviour of political, educational, economic, productive and social macrovariables (i.e. implicit policies).

It is impossible to describe the current status of STI without accurate data. Moreover, these data should be presented in such a way as to allow decision-makers and experts to estimate whether the status of STI meets societal needs or expectations. Policy-makers benefit from additional policy tools to assist them in deciding about budget allocations or in the design of new STI policy instruments, especially if these are real-time tools or new innovative prospective methodologies. Recent empirical studies show the relevance and long-term impact of appropriate STI information services on STI policies designed to improve national competitiveness (Lee and Kim, 2009).

It is also important to note the availability of a large group of public and private databases. These can be most useful tools for evaluating the performance of the STI policies and providing adequate technology intelligence studies. There are robust, accessible systems designed to make rapid analyses and apply mathematical models to identify critical points or levers triggered by policy changes that can directly affect

103 For a detailed list of issues and challenges addressed by engineering policies,see UNESCO (2010).

the performance of innovation activities. For example, Zucker et al. (2011) present a comprehensive survey of all available databases that may be used to analyse the impact of STI policies (see Box 7).

BOX 7 – USING NEW MATHEMATICAL THEORIES TO PROMOTE STRATEGIC NATIONAL INNOVATION

Recent developments in the mathematical theory of networks can be applied to formulating new STI policies, in order to promote strategic innovation within national economies.

Hidalgo et al. (2007) found that 'economies grow by upgrading the products they produce and export. The technology, capital, institutions and skills needed to make newer products are more easily adapted from some products than from others. The study of this network of relatedness between products, or "product space", shows that more sophisticated products are located in a densely connected core, whereas less sophisticated products occupy a less connected periphery. Empirically, countries move through the product space by developing goods close to those they currently produce. Most countries can reach the core only by traversing empirically infrequent distances, which may help to explain why poor countries have trouble developing more competitive exports and fail to converge to the income levels of rich countries'.

This type of analysis can be applied directly to formulating customized STI policy instruments to foster the development of specific technologies, where the country has detected a potential new technological niche. The availability of access to new electronic international databases (Zucker et al., 2011), combined with the appropriate analytic software, might transform this type of analysis into a standard procedure for selecting national STI priorities.

Access to appropriate, reliable data is also a prerequisite for responsible and accountable governance, which demands informed decision-making at the planning stage of STI policy and foresight as to the possible short- and long-term impact of policy decisions. Therefore, policy-makers not only need a clear picture of the national, regional and global situation. They also need to be able to estimate the impact of current STI policies and plan on future policies. The analysis of any national or regional STI policy strongly depends on the adequate mapping of the structure of STI governing bodies, STI national legal frameworks and the implicit and explicit operational STI policy instruments. Gaps or blind spots in information can cause a specific field to be neglected, which can result in missed opportunities for socio-economic development.

POLICY INSTRUMENTS: LEVERS FOR IMPLEMENTING DECISIONS

A policy may remain a mere rhetorical statement if no means are provided for its implementation or to realize its potential effect. To do this, a number of things may be needed, which we will incorporate under the term of 'policy instrument'. A policy instrument constitutes the set of ways and means used when putting a given policy into practice. It can be considered as the vehicle through which those in charge of formulating and implementing policies actualize their capability to influence decisions taken by others.

The study of public policy instruments in national settings has contributed significantly to the understanding of policy, political systems and relations between state and citizen. Research on policy implementation usually focuses principally on the effects of a specific instrument, within a wider reflection on whether the correct instrument has been chosen for the purpose. As far as new governance models are concerned, the search for suitable instruments is above all governed by pragmatism (Kassim and Le Galés, 2010).

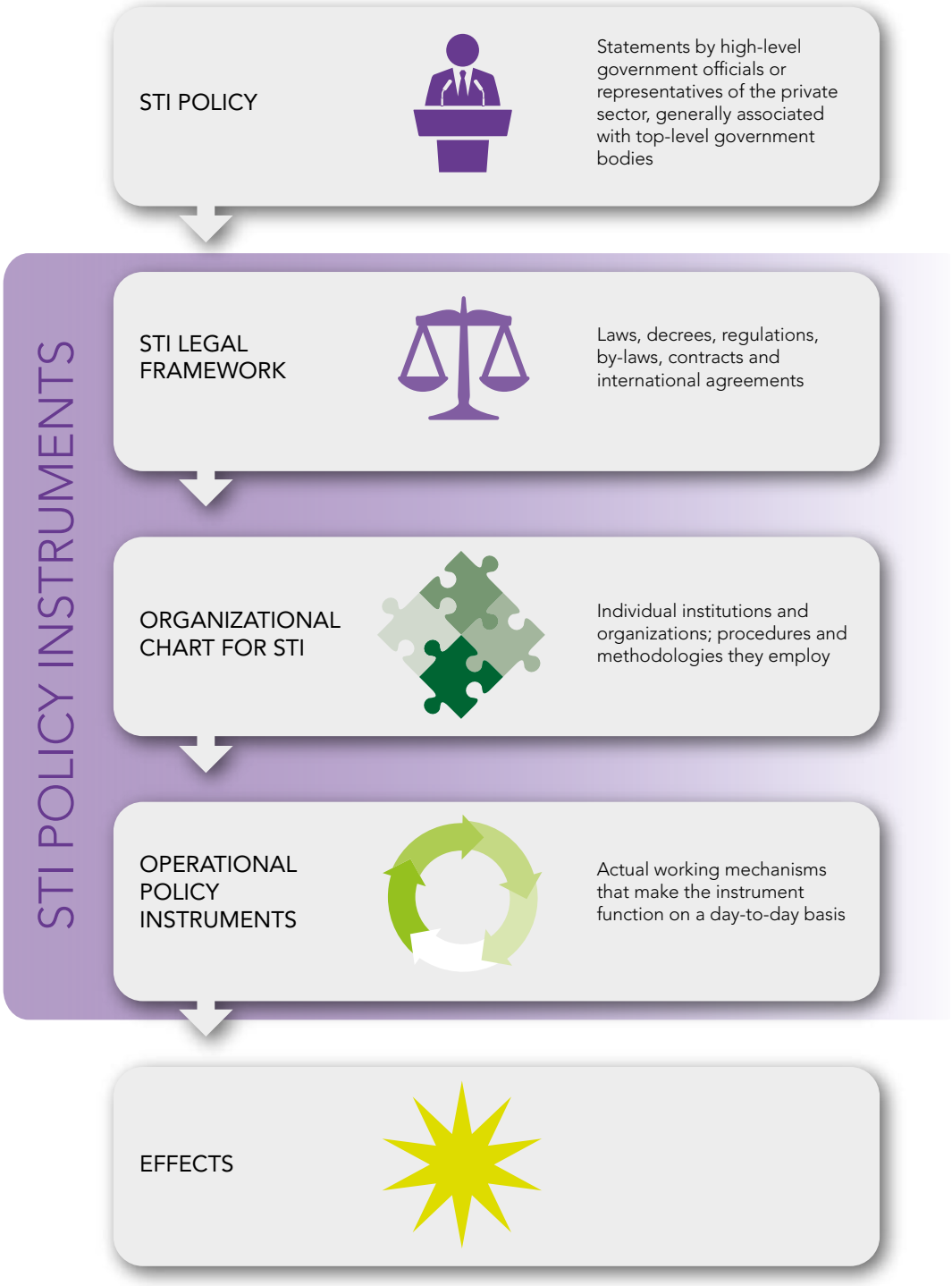

Figure 14. Instruments for ensuring a policy obtains the desired effect. Adapted from Sagasti and Aráoz (1976)
Source: UNESCO's GO-SPIN methodology

STI operational policy instruments are the levers by which the organizational structure ultimately implements decisions on a day-to-day basis and attempts to produce the desired effect on the variables the policy has set out to influence. Throughout the analysis of an instrument's effectiveness, it is important to bear in mind the 'actors' or key decision-makers who are directly involved in the design and use of a policy instrument. An instrument does not act on its own accord. Rather, it responds to the will of the policy-makers and decision-makers using it.

A related concept can be found in the problem of *Ordnungspolitik* stressed by the German Freiburg School in the 1930s. Here, the focus was how to devise a framework or set of rules (*Ordnungsrahmen*) for an economy that would define the operating space for individual and private activities. The challenge for STI policy instruments can be interpreted as a problem of transformation, namely the question of choosing the best policy instrument in order to reach the set target.

A policy instrument attempts to make individuals and institutions take decisions following the rationality dictated by the collective objectives established by those in power. It is the connecting link between the purpose expressed in a policy and the effect that is sought in practice. An STI policy instrument includes, as a significant component, the manipulation of STI variables.

One of the first and more relevant studies on STI policy instruments was conducted in the 1970s by the International Development Research Centre. The principal objective of the study was to devise ways and means of understanding how a country's investment in STI could be most effectively related to its objectives for industrial development. Sagasti and Aráoz (1976) developed an interesting methodological framework for making a survey and analysing the policy instruments of ten countries in Latin America, the Middle East, Southern Europe and Asia.

UNESCO's GO→SPIN[104] has adapted and expanded the theoretical framework of Sagasti and Aráoz (1976), in order to implement a systematic survey in Africa, the Arab States, Asia and the Pacific, and in Latin America and the Caribbean. The information in the present country profile has been organized according to this methodological approach. Figure 14 presents the basic analytical units around which the present report is organized.

All national STI policies, be they *implicit* or *explicit* (Herrera, 1971, 1972), attempt to harness a country's creative potential to its socio-economic, environmental and cultural objectives. An *explicit* STI policy is a statement by a high-level government official or institution, such as a ministry or the planning secretariat, that deals with activities related to STI. The policy expresses a purpose (effects according to STI variables) and may set objectives, define desired outcomes and establish quantitative goals. Policies also contain criteria for choosing from among several alternatives to guide decision-makers as to how STI works. STI policies might also be formulated by representatives of the private sector. A number of factors impinge on the efficiency of STI governance, namely, the extent to which policy processes have the greatest effect with a given use of resources. It must be acknowledged that overall efficiency is not easily defined and measured in a multi-objective, multi-actor world.

THE KEY ROLE OF THE STI ORGANIZATIONAL STRUCTURE IN POLICY IMPLEMENTATION

The STI organizational structure or chart usually shows the distribution of responsibility for implementing a given policy. Under the term 'organizational structure,' it is possible to distinguish at least five different levels: (1) policy planning level (policy design); (2) promotional level (i.e. funding and coordination of R&D, innovation and scientific and technological services); (3) implementation level (execution of R&D and innovation); (4) scientific and technological services; and (5) assessment or evaluation level.

1. *Policy planning level*: includes policy planning, budgeting, decision-making, interministerial coordination. The responsibility for the formulation of STI policies generally rests with a special

104 See https://gospin.unesco.org/frontend/home/index.php

government department, ministry or statutory body, in some cases assisted by national councils of research and innovation. STI policy formulation normally includes the preparation of the national development plan or strategy relating to STI; it also includes the annual preparation of the functional state budget for STI activities (mainly research, innovation and scientific and technological services). The decision-making function usually falls to the government, or to a committee of ministers more specifically concerned with STI; it mainly involves the approval of the national STI plan (or strategy), as well as the assignment of funding mechanisms. The interministerial coordination takes place during the formulation of policies and preparation of plans and budgets then at the various stages of the implementation of these policy documents, once approved by the government.

2. *Promotional level*: the promotion, financing and coordination of research, innovation and scientific and technological services in the various sectors of the economy and in society. The functions performed at this level begin with the policy decisions taken by the government and continue with the various government departments or ministries through traditional budgetary procedures along administrative budget lines or through programme budget procedures, as applied to the so-called management by objectives. Several funding mechanisms and STI operational policy instruments of various kinds have been implemented over the years (i.e. research funds, innovation funds, sectorial funds, tax-incentives, competitive grants, scholarships, etc.). Most countries apply a combination of operational policy instruments to handle the financing of research, innovation and scientific and technological services according to well-defined programmes. The latter can be achieved either by responding to requests for the funding of specific projects submitted by external institutions, laboratories, research units, individual research scientists and high-tech enterprises, or by providing incentives for innovation, or by selectively entrusting the external bodies mentioned above with the execution of specific projects called for by certain development objectives according to the national STI plan or strategy (normative method). At this particular level, several countries have special institutions (i.e. national research councils) which promote the advancement of scientific research and technological development with a view to improving the quantity and quality of new scientific knowledge to expand the country's potentialities, particularly through support for post-graduate education and research at universities and polytechnics.
3. *Implementation level*: this operational level concerns the actual performance of scientific research, technological development and innovation.
4. *Scientific and technological services (STS) level*: this represents a mixed group, including the institutions in charge of: (a) STI information and documentation; (b) museums of science and technology, botanical and zoological parks and other STI collections (anthropological, archaeological, geological, etc.); (c) general purpose data collections: all the activities comprising the routine systematic collection of data in all fields of STI, such as topographical, geological and hydrological surveys, routine astronomical, meteorological and seismological observations, surveying of soils and plants, fish and wildlife resources, atmosphere and water testing, monitoring of radioactivity, UV and CO_2 levels, prospecting and related activities designed to locate and identify oil and mineral resources, gathering of information on human, social, economic and cultural phenomena, usually for the purpose of compiling routine statistics, testing, standardization, metrology and quality control, activities related to patents and licences, as well as the production of scientific publications.
5. *Assessment or evaluation level*: this consists of government sectors and institutions monitoring the implementation of policy goals and measuring the societal impact of those policies. Their function also encompasses the conduct of an ongoing survey of a country's STI potential at the level of research, innovation and scientific and technological service units, including ongoing research results and their practical application.

UNESCO's methodological approach introduced a normalized way of encoding the different types of organization and their functions. By representing each national STI organizational chart and by using the same set of coding tools (Lemarchand, 2010, p. 310), it will be possible in future to associate these charts and tools with specific topological metrics to identify patterns in performance. The latter will be very useful for defining a new set of STI policy indicators able to reveal the level of complexity and functionality of each STI organizational chart. Table 1 shows examples of how different countries structure STI policy design.

Since its purpose is to guide decisions about the future that must be taken now, a STI watch cannot seek to identify future developments in STI independently of past and current developments, or independently of the material and human resources devoted to research and innovation. The prerequisites for any future are: knowledge of the present, knowledge of the current trends observed in a real world composed of different nations and institutions, and knowledge of the strength and weaknesses of the national STI system in which the decisions informed by the GO→SPIN survey's methodological approach have to be taken.

Table 1. Models of governing bodies heading STI policy design

Argentina	Scientific and Technological Cabinet (GACTEC) Ministry of Science, Technology and Productive Innovation
Australia	Prime Minister's Science Engineering and Innovation Council Commonwealth State and Territory Advisory Council on Innovation Coordination Committee on Innovation
Chile	Inter-ministerial Committee for Innovation National Corporation for the Promotion of Production (Ministry of Economy) National Commission for Scientific and Technological Research (Ministry of Education)
Croatia	Ministry of Science, Education and Sports National Council for Science National Council for Higher Education
Czechia	Ministry of Industry and Trade Council for Research, Development and Innovation Ministry of Education, Youth and Sports
Finland	Research and Innovation Council Ministry of Employment and the Economy Ministry of Education and Culture
Ireland	Inter-Departmental Committee on STI Department of Jobs, Enterprise and Innovation
Malaysia	Ministry of International Trade and Industry Ministry of Science, Technology and Innovation Economic Planning Unit
Republic of Korea	National Science and Technology Council Ministry of Science and Technology
Singapore	Economic Development Board Research, Innovation and Enterprise Council National Research Foundation
South Africa	Department of Science and Technology Department of Trade and Industry Department of Higher Education and Training

Source: UNESCO GO-SPIN platform

The diversity of institutions at the promotion level (funding) in a given country seems to be one of the most fundamental indicators of good practices. The GO→SPIN platform provides empirical evidence to confirm or refute this and other hypotheses.

The so-called *legal framework* can also be considered as a set of legal instruments. This embodies the policy, or parts thereof, in the form of a law, decree or regulation. Formal agreements, contracts and international STI cooperation treaties may also be included in this category. A legal instrument goes one step beyond a policy by stipulating obligations, rights, rewards and penalties. The GO→SPIN systemic approach has developed a friendly platform offering direct access to the entire STI legal framework, description and the full text of laws, acts, decrees and agreements adopted by each country. Table 2 shows different examples of the most important types of legal instrument.

Table 2. Examples of STI legal instruments

A law for the creation of national research labs, universities, national research councils, ministry of S&T, R&D funds, etc., or a legal framework to regulate the organization of the national innovation system.
A law to regulate the imports/exports of high-tech products.
A law to regulate tax incentives to promote innovation within the private sector.
A law to regulate foreign direct investments promoting the establishment of new high-tech enterprises.
A law to regulate the protection of the national biodiversity and to establish norms on how foreign companies exploit the active substances available within each national territory (new rules for the protection of indigenous knowledge).
Laws to foster R&D activities within the private sector and the creation of technological funds associated with the most strategic sectors of the economy (energy, mining, agriculture, industry, communication, fishing, tourism, etc.).
National regulations and decrees to establish new national policies, creation of new funding mechanisms, import/export tariffs, etc.
Bilateral, regional and international agreements on STI activities.
Contracts on technology transfer.

Source: UNESCO GO-SPIN platform

UNESCO's methodology also includes a complete description of STI operational policy instruments; these are the levers, or actual means, through which the organizational structure ultimately implements the decisions on a day-to-day basis and attempts to influence the behaviour of the various stakeholders targeted by the policy. Table 3 shows different types of operational policy instrument, whereas Figure 15 shows various instruments that can be employed to effect at the different stages leading to market penetration of an innovation. Table 4 presents the taxonomic classification of STI operational policy instruments employed by GO→SPIN according to its methodological approach, by objective and goal; the type of mechanism/mode of support and target groups/beneficiaries. By analysing the aggregated information for groups of countries employing these classification schemes, it is possible to detect development patterns.

Table 3. Examples of operational STI policy instruments

Programmes and objectives	Policy instrument	Strategic objectives	Beneficiaries	Mechanisms for allocating funding
Scientific research and technological development	Competitive grants	Promote the endogenous production of new scientific knowledge in the exact and natural sciences. Promote regional networking.	Research groups at national universities and national research centres associated with similar research groups from other countries in the region, within formal partnership agreements	Competitive grants selected on a peer review basis; national research groups must be associated with similar groups from countries in the region which provide matching funding
Promotion of science education	Public subsidies for projects establishing science laboratories at public secondary schools	Improve scientific knowledge; methodological approach and critical thinking for secondary school pupils	Public secondary schools in less developed parts of the country	Public subsidies to mount new science cabinets and laboratories and new posts for science professors
Promotion of gender equality in research and innovation	Scholarships	Promote the participation of women in high-tech research and innovation	Young women enrolled in a Ph.D. programme in basic and engineering sciences	Scholarships of up to four years and small grants for participation in international conferences

Programmes and objectives	Policy instrument	Strategic objectives	Beneficiaries	Mechanisms for allocating funding
Protection of indigenous knowledge	Intellectual property rights, public law–national legislation and public subsidies	Protection of traditional knowledge to confer exclusive ownership and rights on local communities when the object of protection is a product or domesticated animal, cultivated plant or any micro-organism, or a design or an object of a functional or aesthetic nature, including any element of handicrafts, the act prohibits third parties from making, using, stocking, offering for sale, selling, commercializing, importing, exporting or identifying the active substances for commercialization, without consent	A local traditional practitioner, a local community or its representative may apply to register traditional knowledge	Public subsidies and tax exemptions to defend the intellectual property rights of holders of indigenous and traditional knowledge
Attraction and reinvestment of foreign direct investment	Public financing Tax incentives	Strategies vary from country to country, examples being: (a) an industrial policy based on attracting export-oriented industries; (b) promotion of structural change; (c) capacity-building to improve competitiveness, focusing on sectors or market niches; (d) internationalization of enterprises and promotion of innovation; (e) prioritizing the generation of higher-tech goods and services; (f) attracting selective FDI oriented towards ICTs, biotechnology, nanotechnology and financial services; (g) improving the business climate by refining legislation and simplifying formalities to facilitate corporate operations.	National infrastructure (buildings, technology corridors, technological cities) and training of labour and professionals for the industry in question SMEs with export capacity	Soft loans, tax incentives, grants For specific periods: tax discounts, exemptions, preferential rates, rebates on machinery and equipment
	Attracting R&D firms		Endogenous entrepreneurs High-tech emerging sectors: biotechnology, nanotechnology, new materials, ICTs.	The same tax incentives plus special competitive funding
	Other services	Structural change within a large country offers more opportunities for the domestic market, small and medium-sized countries generally focus on schemes conducive to the development of exports	Strengthening exports of industries and services considered to have strong potential in the country	Creation of a 'one-stop shop' with representatives from different ministries/ agencies to deal with problems concerning programmes, public regulations and post-investment services
Technological development	Non-repayable contributions	Increased competitiveness through innovation in products, services and processes	Micro-, small and medium-sized enterprises and broader enterprises certified as having attained international standards	By public competition; up to 50% of project cost
	Loans for technological development projects	Finance for middle-income technology production projects	Micro-, small and medium-sized enterprises with R&D departments or teams, collaborating groups and technical linkage units underwritten by the enterprise	Compulsorily repayable loans; up to 80% of the total cost, allocated on an open window basis, with a maximum of $... for three years
Technological modernization (improvement of products and processes, training)	Fiscal credit programme	Assistance in executing R&D	Physical or juridical persons who own enterprises producing goods and services	Subsidies through fiscal credit certificates obtained via public competition; up to 50% of the total cost of the project
	Loans for modernization projects	Technological adaptation and improvements to products and processes with a low level of technical and economic risk	Enterprises with R&D departments or groups; collaboration groups, and technical linkage units underwritten by the enterprise	Special compulsorily repayable loans allocated on an open window basis. Up to 80% of the total cost of the project, with a maximum of $...in three years

Programmes and objectives	Policy instrument	Strategic objectives	Beneficiaries	Mechanisms for allocating funding
	Loans to enterprises	To finance projects for the development of new production processes, products and modifications thereto	Enterprises, without any restriction on size or sector; no finance provided for projects with a rate of return of less than 12%	Compulsorily repayable loans allocated on an open window basis. Up to 80% of the total cost of the project, with a maximum of $...
Promotion of the technological services market (research institutes and business research centres)	Subsidies for projects to develop business plans	Finance for business development projects based on R&D	Micro-, small and medium-sized enterprises whose projects are executed by technical linkage units	Subsidies allocated on an open window basis. Up to 50% of the total project cost, with a maximum of $..., for up to one year
	Loans to institutions	To promote the establishment and strengthening of structures for the provision of technological services to R&D enterprises and institutions	Public or private institutions providing services to the private productive sector; projects may be presented on an individual or associated basis	Obligatorily repayable subsidies allocated on an open window basis, up to a maximum of $...
Training and technical assistance	Subsidies for training and retraining projects	Subsidies to support activities for training and retraining human resources in new technologies	Micro-, small and medium-sized enterprises whose projects are executed by technical linkage units	Subsidies allocated on an open window basis. Up to a maximum of 50% of the total cost of the project, or $... for up to six months
	Subsidies for project formulation	Support for the formulation of R&D projects, technology transfer or technical assistance	Micro-, small and medium-sized enterprises whose projects are executed by technical linkage units	Subsidies allocated on an open window basis. Up to a maximum of 50% of the total cost of the project, or $... for up to six months
Technological advisory assistance programmes and those strengthening the performance of technical small and medium-sized enterprises	Technological advisory assistance programme	Support for the formulation of R&D projects, technology transfer or technical assistance	Micro-, small and medium-sized enterprises producing goods and services which incorporate technological added value	Subsidies allocated on an open window basis to individuals or groups, with a maximum of 50% of the total cost of the project, or $... and a maximum of $... per participating enterprise
Popularization and social appropriation of science	Competitive grants	Support for the organization of national exhibitions and science fairs	Science museums, educational institutions at primary, secondary and tertiary levels	Subsidies allocated on a competitive basis

Source: UNESCO, UN ECLAC, FONTAR (Argentina)

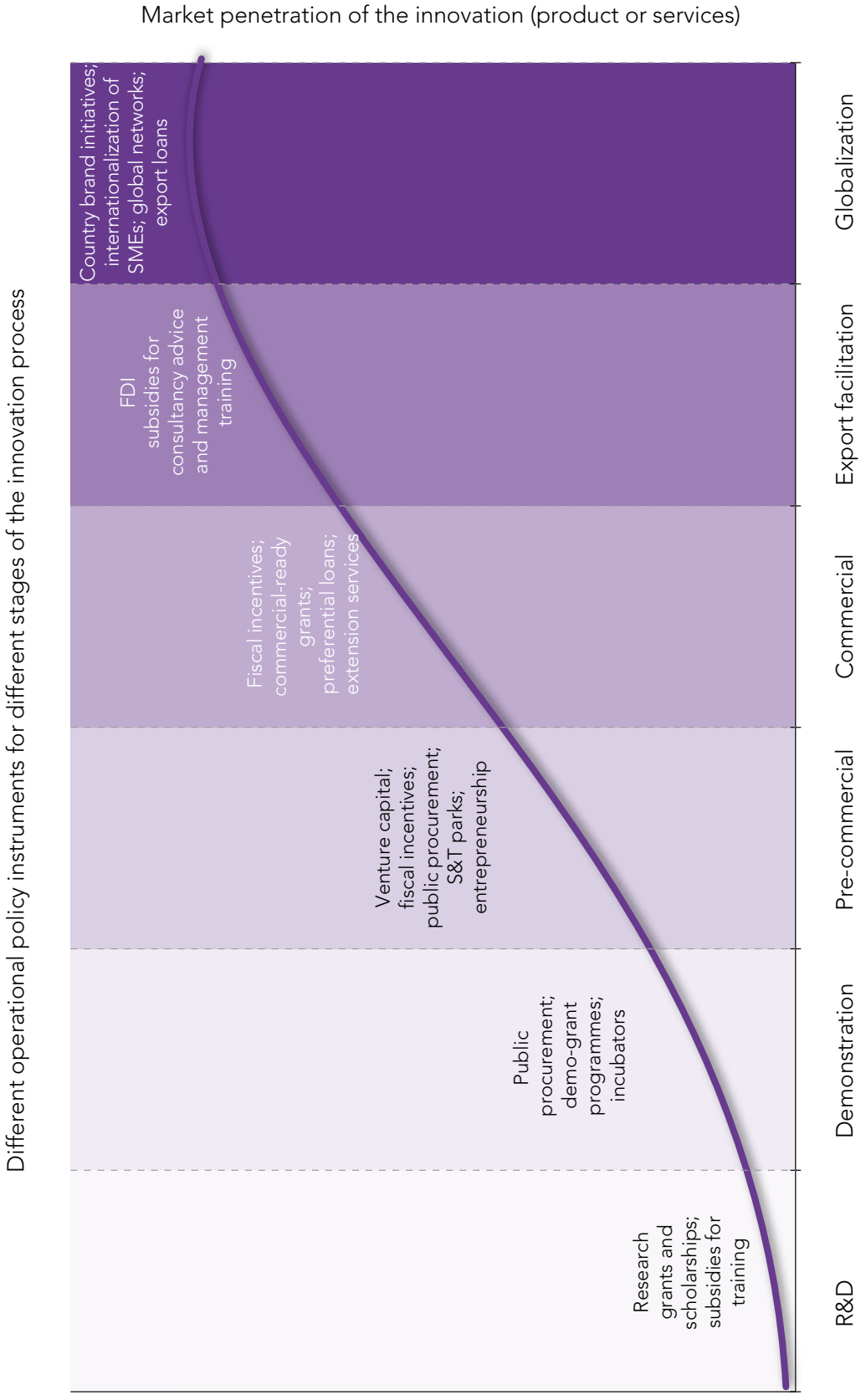

Figure 15. Policy instruments for different stages of the innovation process and market penetration
Source: UNESCO GO-SPIN platform

Table 4. Taxonomic classification of STI operational policy instruments employed by UNESCO

Objectives and goals	Type of mechanism/ Mode of support	Target groups/ Beneficiaries
• Strengthen the production of new endogenous scientific knowledge • Strengthen the infrastructure of research laboratories in the public and private sectors • Human resources for research, innovation and strategic planning; capacity building, education and training of specialized human capital for (1) the production of new scientific knowledge, (2) development of new technologies, (3) promotion of innovation within the productive and services systems and (4) management of the knowledge society • Strengthen gender equality for research and innovation • Strengthen the social appropriation of scientific knowledge and new technologies • Development of strategic technological areas and new niche products and services with high added value; promotion and development of innovation in the production of goods and services; promotion of start-ups in areas of high technology • Strengthen science education programmes at all levels (from primary school to postgraduate) • Promotion of the development of green technologies and social-inclusion technologies • Promotion of indigenous knowledge systems • Research and innovation eco-system: strengthening coordination, networking and integration processes which promote synergies among the different actors of the national scientific, technological and productive innovation system (i.e. government, university and productive sectors) • Strengthen the quality of technology foresight studies to: assess the potential of high-value markets; develop business plans for high-tech companies; construct and analyse long-term scenarios; and provide consulting services and strategic intelligence • Strengthen regional and international cooperation, networking and promotion of STI activities	• Grants (grant funds) • Donations (individuals/ companies) • Loans • Creation of, and support for, technological poles and centres of excellence • Tax incentives • Technical assistance • Scholarships • Credit incentives and venture capital • Trust funds • Information services • Others	• Individual researchers or professionals, Ph.D. holders, higher-education teachers. • Research groups • Technical and support staff for STI activities • Graduate students • Universities, colleges, tertiary education institutions (public or private) • Secondary and primary schools (public or private) • Institutes and other research centres (public or private) • Technical training centres (public or private) • Business/enterprises (public or private) at different categories (corporations, SMEs, etc) • R&D non-profit organizations (public or private) • Foundations (public or private) • R&D Professional Associations • Ad hoc associations • Cooperatives related with STI • Other

Source: UNESCO GO-SPIN platform

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UNESCO's Global Observatory of Science, Technology and Innovation Policy Instruments (GO→SPIN) country profiles series is designed to expose – through the rigorous application of an assessment lens – usable insights about science, technology and innovation (STI) policies and their context. This is meant to encourage choices that harness research and innovation to achieve national goals.

Uzbekistan is highly committed to STI as a vital tool for achieving socio-economic development, and determined to attain the ambitious goals set to be achieved by 2030. Since the country gained independence in 1991, the leadership changed for the first time at the end of 2016 with the election of the new president. After assuming office, President Shavkat Mirziyoyev initiated reforms not only to establish a market-oriented economy and improve the business climate, but also to increase investment in R&D and innovation as well as the commercialization of research results.

As Uzbekistan moves towards creating an innovation-driven economy, it needs to build up a fully-fledged national innovation system (NIS), pursue more effective STI governance, create a balanced STI policy mix and continue to invest in building STI capacities. The innovation system of Uzbekistan is evolving rapidly and several elements of it are at a nascent stage. At this stage of development, there is a need to avoid task duplication and fragmentation, and enhance coordination between NIS institutions. Dynamizing the NIS in Uzbekistan also requires encouraging the creation of innovation intermediaries and service providers to facilitate the creation, diffusion and use of knowledge, technology and innovation. As rightly brought to the fore by the government recently, reducing the regional disparities in Uzbekistan and addressing region-specific challenges necessitates a special focus on the development of local and regional innovation ecosystems.

Currently, the majority of the STI policy instruments in Uzbekistan concentrate on research performers and start-ups, with the primary focus being research commercialization, mainly through start-up projects. Thus, there is a need to develop and maintain a balanced policy mix. Achieving progress and success in this process requires the development of skills and capacities in STI policy making and implementation. Capacity building is also needed for the management teams and researchers in the research institutes, universities and the private sector. Furthermore, motivating the younger population towards STEM careers from an early age, engaging students in meaningful real-life problem-solving situations throughout the educational life cycle, and increasing the participation of women in research, higher education and STI-driven entrepreneurship are important for achieving sustainable and innovation-based development.

In this volume *Mapping Research and Innovation in the Republic of Uzbekistan*, the Islamic Development Bank, the Government of Uzbekistan and UNESCO have collaborated to prepare an evidence-based policy analysis of Uzbekistan's STI profile. The present profile aligns with the methodology of the Global Observatory of Science, Technology and Innovation Policy Instruments (GO→SPIN), a UNESCO tool to map research and innovation at country level.

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