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SCIENCE AND TECHNOLOGY

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Contents

The countries dealt with in this chapter had many things in common, but also many differences in the mid-nineteenth century. They were all agricultural subsistence economies. North India, Pakistan and Iran had a mainly sedentary population, while Afghanistan, Xinjiang, Mongolia and the Central Asian khanates had a mainly nomadic population. Only Iran, North India and Pakistan had many large urban centres, although each of the other countries had at least one major primary city (e.g. Bukhara, Tashkent, Khiva, Kabul). All but two of the countries had a majority Muslim population. North India, although also mainly Muslim, still had large Hindu and Sikh minorities, while Mongolia was Buddhist. Most of the countries were sparsely populated, with the exception of North India and Pakistan. All these societies had a population with a low literacy rate of 5 per cent or less.

Education was traditional, mainly urban-based, religious in nature and not focused on the questioning of authority, whether of a scientific or other nature.

From the 1850s the Central Asian khanates were gradually incorporated into imperial Russia, a process that was completed with the occupation of Bukhara in 1920. North India and Pakistan were under British rule, while neighbouring Afghanistan remained formally independent, as did Iran. Both countries were under great political, military and economic pressure from Russia and Britain, however. Xinjiang and Mongolia were under nominal Chinese rule. For most of the countries concerned, a major change took place following the Russian revolution of 1917, when communist ideology became the developmental creed of the Central Asian countries and Mongolia (for Xinjiang, this only occurred as of 1949, with the establishment of communism as the state ideology in China). What are today India and Pakistan remained under British rule until 1947, but thereafter the two independent states chose their own (still strongly centralized) development path. Iran, and to a lesser extent Afghanistan, continued an equally centralizing monarchist rule. From 1978 to 1989, Afghanistan was a communist-ruled state; the ensuing civil war was ended by the take-over by the Taliban regime, which had a fundamentalist Muslim ideology that is utterly anti-science and -technology. Iran's Islamic revolution of 1979 led to a regime that was based on a different kind of Muslim ideology, one that actively promotes science and technology.

Following the organizational pattern of the Soviet model for the fields of science and industry, all the Central Asian republics as well as Mongolia and Xinjiang separated education, production and research activities. Research was pursued in specialized research institutes, while little research was done at universities. Under communist rule, centralized science and technology directives were laid down by Moscow – this is still the system in Xinjiang (but from Beijing). Mongolia, although formally independent, also followed the Soviet model and its instructions. During the Soviet era, Russian, rather than the national languages, was the preferred medium of instruction in higher education. The same still holds true for Xinjiang, where Chinese is the main language of science and technology.

By the early 1960s, each Soviet republic had its own academic research centre – the Republican Academy of Sciences and its affiliated branch and section institutes. The aims of the academy are to carry out scientific research in the natural, technical and social sciences, to train scientific staff in all fields of science, to advise the government in matters of scientific policy and to disseminate knowledge. The academy defines priority themes and directions of research in the national academies, coordinates fundamental research financed by the state, participates in international organizations and organizes symposia and conferences to discuss scientific problems and coordinate research.

As a result of the radical socio-economic reforms in the communist countries, all the social indicators (health, education, income) experienced significant improvements. This was not the case in the other countries discussed here. Afghanistan is now only slightly better off than it was in 1900, while North India and Pakistan have made some progress; only Iran has been able to develop consistently. In most countries, the private sector now plays a positive role, although in all countries with a communist past and/or communist present most research and development is still done in state-owned institutions. Whereas in the past this same group of countries had little or no international contacts (other than with like-minded communist states), these are now eagerly sought for the funds and the knowledge that such contacts bring.

Although the ratio of Gross domestic Expenditure on Research and Development (GERD) to Gross Domestic Product (GDP) and the number of personnel involved in the science and technology sector serve as indicators for its importance and progress at the national level, the data require critical evaluation. One important indicator is the number of articles published in internationally respected journals or the number of patents registered in the international patent systems. A second criterion for scientific achievement is the degree to which science enters into a nation's economy. Third, and last, a nation's scientific level is estimated by the quality of science taught in its educational institutions, and the extent to which scientific thinking is part of the general public consciousness. Among the indicators, research and development expenditures, scientific output as publications and frequency of citations seem to be the most clearly defined and least controversial parameters. As to the qualitative aspect, the reader is referred to the Institute for Scientific Information's *Journal Citation Reports*: these present quantifiable statistical data that provide a systematic, objective way of evaluating the world's leading journals and their impact and influence in the global research community.[1]

As far as the quantitative aspect is concerned, most of the countries with which we are concerned perform badly. On average, 1.8 per cent of national GDP has been spent on research and development worldwide. The leastdeveloped countries (LDCs) devoted less than 1 per cent (0.9 per cent) of their GDP to research and development in 2000, whereas the more developed countries generally spent 2.4 per cent of GDP. From Table 1 it is clear that the countries discussed have a below-average GERD, particularly those countries for which no data are available. There are on average 10 times more researchers per million inhabitants in the more developed countries than in the LDCs. Three out of every 1,000 inhabitants of the more developed countries are researchers, while only 3 out of every

[1] See http://www.isinet.com/.

TABLE 1. Personnel engaged in, and expenditure on, research and development (1997 unless otherwise indicated)

Country	No. of researchers per million inhabitants	No. of technicians per million inhabitants	No. of technicians per researcher	Expenditure on R& D as percentage of GNP
Afghanistan	–	–	–	–
India (1994)	149	108	0.7	0.73
Iran	560	166	0.3	0.48
Kazakhstan	716	293	0.4	0.29
Kyrgyzstan	581	49	0.1	0.19
Mongolia	544	78	0.1	–
Pakistan	72	13	0.2	–
Tajikistan (1993)	666	–	–	–
Turkmenistan –	–	–	–	–
Uzbekistan (1992)	1,763	314	0.2	–
Xinjiang –	–	–	–	–

Source: UNESCO [http://www.uis.unesco.org/TEMPLATE/html/SandTec/Table_III_1_Asia.html].

10,000 inhabitants are researchers in the LDCs according to UNESCO. In this respect, some of the countries discussed here perform better than average.

Afghanistan

Afghanistan is traditionally an agricultural and pastoral-based society. In urban areas, handicrafts prevail. Social indicators are still among the worst in the world. The people are divided by tribal affiliations reinforced by the natural geographic divisions of the country. Education continues to be mainly restricted to religious instruction, a system preferred by tradition-bound families, and hence literacy is lower than 5 per cent. Religion is still the binding force between the various groups and there is strong resistance to change. As a result, developments in science and technology during the last 150 years have bypassed most of Afghanistan's population.

Amir ‘Abd al-Rahman (1880–1901) tried to forge a nation from the splintered regions comprising Afghanistan and attempted to modernize his kingdom. His son Habibullah (1901–19) brought foreign physicians, engineers (especially for mining), geologists and printers to Afghanistan. He imported European machinery and encouraged the establishment of small factories to manufacture soap, candles and leather goods.[2] After his assassination, his son Amanullah (1919–29) tried to continue his father's modernizing policies.

[2] Thornton and Thornton, 1910.

His social and educational reforms included the introduction of secular education (for girls as well as boys), adult education classes and education programmes for nomads. This policy led to his abdication in 1929 and most of his proposals were never carried out – the amir had failed to involve the tribal and religious leaders in his plans, which they resisted. Under Amir Amanullah, some attempts were made to introduce modern education, but the lack of qualified administrators as well as science and technology personnel constrained development. Most notable was the establishment of the College of Medicine in 1932 under Nadir Shah (1929–33). Some small factories were also established in the 1930s (textile, sugar, oil processing). This development was interrupted by the Second World War, but restarted in the 1950s.[3] However, manufacturing is still in its infancy in Afghanistan. By 1980 there were only some 200 manufacturing establishments in the country. This was partly due to the lack of infrastructure, in particular the lack of qualified technical personnel to plan, identify, execute and manage industrial projects.

After the establishment of the Afghan revolutionary government in 1978, illiteracy was recognized as the major factor hindering the country's development and preventing the people benefiting from modern science and technology. The first census in 1977 showed that the literacy rate was around 11.4 per cent (18.7 per cent for males; 2.8 for females), with a strong economic, regional and gender bias. The urban population was more literate than the rural, and men more literate than women. People in Kabul province had greater access to education than elsewhere in the country. The new government therefore gave high priority to the expansion of education. In theory education was free from kindergarten through university, but in practice the lack of educators and schools made this policy objective unattainable. In fact, much of the higher training for technical personnel was undertaken in a small number of modern factories, and it was limited to their own staff. Some specialized government agencies (radio and television; civil aviation; Ministry of Mines) did the same. The Ministry of Public Health ran its own nursing school. Those wanting higher education had to go abroad.

Science and technology had been largely ignored in the development plans of successive governments since the Second World War. The first scientific research activities took place in 1956, when the Department of Agricultural Research and Soil Science was created. There was also an institute that dealt with surface water investigations attached to the Ministry of Water and Power. In 1963 the Kabul University Research Centre was established: it was supposed to become the driving force behind the development of science and technology. The centre, however, was unable to fulfil this role. There was a lack of funds, little political support, and the few science and technology activities that took place were

[3] Wilber, 1962.

financed by foreign countries and the United Nations. There was also a mismatch between the type of technical education that students received and the needs of domestic industry. Furthermore, much science and technology work had been in the form of technical assistance by foreign experts who did not ensure the build-up of know-how in Afghanistan through the transfer of science and technology. Finally, through the brain drain, many Afghan students studying abroad decided to remain there.

The revolutionary government also wanted to develop the science and technology base of the country in all aspects. To that end in 1979 it created a National Science and Technology Commission chaired by the prime minister. Its task was policy formulation, coordination of research and development, mobilization of funds, and development of incentives to check the brain drain. At the same time, science and technology was better embedded in the national development planning process. To that end, the National State Planning Commission had a Science and Technology Unit that was supposed to liaise with the Science and Technology Commission and science and technology agencies to ensure that research and development matched national needs, both upstream and downstream. In 1978 the government had established an Academy of Sciences attached to the prime minister's office as the highest institution to carry out scientific research in the country. Its major area of responsibility was the encouragement of research and development and its effective use in the natural and social sciences.[4]

Given the structural problem of lack of funds, many of the science and technology activities were made possible due to bilateral and multilateral aid. In particular, the Soviet Union and East European communist countries provided much assistance in training thousands of students and providing laboratory equipment and technical services. Considerable support was also received from India in the form of experts and equipment. However, as had been the case over the previous 100 years, science and technology could not develop properly due to the unresolved socio-political problems in Afghanistan, which repeatedly led to political instability. Governments, whose focus is political consolidation, if not survival, have little time for science and technology.

In 1979 the Russian invasion took place, leading to the war of national resistance and eventually to the fall of the communist government in 1989. Then followed a civil war, and the take-over of much of the country by the Taliban regime to whom science and technology was an anathema. With the fall of the Taliban regime in 2001, Afghanistan, once again helped by the international community, has another chance to make science and technology an integral part of its development process.

[4] Gopal, 1987.

Iran and the Islamic Republic of Iran

Iran was an agriculture-based society with a low literacy rate and very low social indicators. In reaction to military defeats against Russia, it started around 1810 to import modern military technology and to send some students abroad for training. The printing press was introduced in 1817 and an increasing number of books and (after 1850) newspapers were published. It was only in 1852 that the *Dār al-Fonūn* (Polytechnic), the first modern tertiary institution in Iran, was established. Foreign teachers taught children of the elite the principles of modern science and modern languages, and access to this institution was very selective. At the same time, the government continued to send a number of students abroad for training, while a few went at their own expense. Moreover, the government employed a number of foreign experts for specialist training.

In 1865 the telegraph system was built on Iranian territory. In 1882 the first scientific bi-weekly (*Dānesh*, or Knowledge) was published, of which only 14 issues appeared. A number of publications on medical subjects by Iranian physicians appeared around the beginning of the twentieth century, while the Pasteur Institute was established in 1922 in Tehran. Despite these first steps, Iran had only 905 doctors trained in modern medical science by 1924. Under the modernizing Pahlavi regime, the *Dār al-Fonūn* was transformed into the University of Tehran in 1934. In 1935 the Academy of Iran was established. Its task was to preserve the Persian language and Persian literature. Many students were sent abroad to learn the skills needed to sustain the industrialization and modernization programme. Gradually, provincial and other national universities were established in the following four decades. During this period the student population increased very slowly so that the total enrolment reached 176,000 in 1979.[5]

With the establishment of the Ministry of Science and Higher Education in 1967, public and private universities and other higher education centres were given a uniform structure. After the Islamic revolution in 1979, major changes took place in the higher education system. To ensure that the new policies and institutions reflected the goals of the Islamic Republic of Iran, the Ministry of Science and Higher Education was set up; it was later renamed the Ministry of Science, Research and Technology (MSRT). It is responsible for the management and planning of higher education organizations in Iran, including universities, colleges and other non-profit and governmental organizations. It also manages most of the larger Iranian research institutes.

To assist the government in policy-making regarding research and to provide support for researchers, the Scientific Research Council was established, with the first vice-president

[5] Ringer, 2001; Floor, 2004; Menashri, 1992.

acting as its chairperson, and with a number of ministers and outstanding researchers acting as members. The Supreme Planning Council – chaired by the minister of culture and higher education – formulates and adopts all educational programmes and regulations with the assistance of university lecturers, and ensures that the universities maintain a satisfactory level of scientific activity. The Higher Education Expansion Councils at the Ministry of Culture and Higher Education and the Ministry of Health, Treatment and Medical Education are responsible for planning and monitoring the establishment and expansion of higher education and research units. The universities and other higher education and research institutions are administered and managed under the supervision and with the financial support of boards of trustees chaired by the minister, and with the chancellor of the university or director of the research centre acting as the secretary. The University Council is responsible for planning the educational and research programmes.

Other specialized institutions in the field of science and technology include the Academy of Iran's Language (1970) and the Academy of Literature and Arts (1974). These academies merged into the newly established Institute of Cultural Studies and Research in 1981. In addition, the Academy of Sciences of the Islamic Republic of Iran (1988), the Academy of Persian Language and Literature (1990) and the Academy of Medical Sciences (1991), with their various scientific departments, have been created. Under MSRT, the Iranian Research Organization for Science and Technology (IROST) was established in 1980 to promote scientific and research activity in the country.[6] The Iranian Scientific Documentation Centre (IRANDOC), established in 1968 and restructured in 1991, is a research centre affiliated with the Ministry of Science, Research and Technology; its task is to expand and develop information science and services through research, education and the provision of services.[7] In 1998 the Iran Industrial Estates Corporation (IIEC), affiliated with the Ministry of Industries and Mines, was instructed to initiate a programme for the development of knowledge-intensive industries (technology parks) within three metropolitan areas. For this purpose, a new vice-presidency for the development of high-technology zones was created within IIEC.

The government realizes that the judicious use of science and technology determines a country's place in the world, politically, economically and socially. Government science and technology policy is therefore aimed at: raising the research share in GNP and improving quantitative and qualitative indicators of research in Iran; directing research activities towards meeting societal needs and further application of research projects of universities and research centres; establishing advanced research centres of excellence at national,

6 For details, see http://www.msrt.gov.ir/English/index.html.
7 For more information, see irandoc-website.

regional and global levels; and, finally, strengthening and developing scientific, educational and research cooperation with international scientific centres and institutions.[8]

Such a policy is vital because, with about 0.1 per cent of its GDP allocated to research and development in 1979, but only 0.2 per cent in 1997 (after a rise to 0.48 per cent in 1994), the Islamic Republic of Iran ranks far behind industrialized societies and even the world average of 1.8 per cent or the 0.9 per cent average of the LDCs. As in the case of higher education, there may have been too much emphasis on quantity. Much science is being produced in Iran but it does not yet necessarily reach the standard necessary for incorporation into world knowledge.

Finally, the brain drain is a major problem for Iran. The latest figures released by the International Monetary Fund (IMF) indicate that Iran ranks first in the brain drain among 61 developing countries and LDCs.[9] Unofficial figures also indicate that over 4 million Iranians live abroad, many of them having emigrated in search of gainful employment. Each year, between 150,000 and 180,000 Iranians try to leave the country by various means. According to the latest published statistics in Iran, some 420,000 Iranian young adults holding top-level university certificates are currently abroad in search of better job opportunities and more satisfactory living conditions.[10]

Kazakhstan

The Kazakh traditional economy was based on herding by transhumant nomads. With the Russian conquest of Kazakhstan by the middle of the nineteenth century, this nomadic lifestyle came to an end as rangelands were converted into croplands due to successive waves of Russian and Ukrainian immigrants. This process had greatly accelerated by the beginning of the Russian revolution (1917). Nevertheless, the establishment of the Research Institute of Veterinary Science (1925), the first of its kind in Kazakhstan, is an indication that animal husbandry was still a major economic activity. As of 1933, several research and development institutes had been established, four of them in the 1930s (Economics and Organization of Agro-Industrial Complexes; Sheep-Breeding; Farming; Agriculture). This was followed by a new wave of 10 institutes in the 1940s (Geological Sciences; Biotechnology and Reproduction of Animals; Potato- and Vegetable-Growing; Human and Animal Physiology; Zoology and Animal Genetics; Chemical Sciences;

[8] For an outline of the government's policy, see www.msrt.gov.ir/English/Policy/Policies.htm.

[9] International Monetary Fund, 1999: http://www.imf.org/external/pubs/ft/fandd/1999/06/carringt.htm.

[10] http://www.payvand.com/news/02/may/1077.html; Torbat, 2002, pp. 272–95; *Indicateurs scientifiques et technologiques 2003*, see http://europa.eu.int/comm/research/press/2003/pdf/indicators2003/3-brain-drain_fr.pdf.

Mining Art; Metallurgy and Ore Concentration; Soil Science (1945); History and Ethnology). In the 1950s there was a third wave (Water Management; Agrarian Research; Plant Protection; Meat and Dairy Products; Astrophysics; Nuclear Physics; Physiology and Labour Hygiene; Microbiology and Virusology; Chemical Metallurgy; Non-Ferrous Metals).[11]

In the 1940s many European Soviet citizens and much of Russia's industry were relocated to Kazakhstan due to the Nazi threat. Furthermore, groups of Crimean Tatars, Germans, and Muslims from the north Caucasus region were deported to Kazakhstan. The establishment of new factories and development projects also made demands on the science and technology capacity: this explains why so many new institutes were created. For the same reason, the National Academy of Sciences of the Republic of Kazakhstan was founded in 1946. Research was carried out in a number of areas, including: earth sciences, mathematics, informatics, physics, remote sensing and space technologies, chemistry, new materials, biologically active substances, biochemistry and physiology of plants, botany, soil sciences, social and humanitarian sciences. More non-Kazakhs arrived in the years 1953–65, during the so-called Virgin Lands Campaign, when much pastureland was transformed into cereal-growing land. More Russians came to Kazakhstan during the 1960s–70s, drawn by the high wages offered to workers who were prepared to move with Russian industrial enterprises that relocated to be closer to the rich energy resources of Central Asia. As a result, the majority of the population became non-Kazakh.

After independence in 1991, the Ministry of Education and Science was made responsible for the formulation and implementation of state policy in the field of education and science, and for general scientific and methodical guidance over all educational and scientific institutions. The ministry, which was created in 1992 to coordinate national science and technology activities, controlled most funding for the Kazakh Academy of Sciences and other scientific institutes in the country. In 1992 the Kazakh Science Foundation was created as an independent non-governmental organization (NGO). In 1993 the foundation's budget was 1.5 billion roubles, which it received from a variety of sources, including transfers from the government budget, subsidies from ministries, contributions from enterprises and grants from foreign organizations. Proposals in the area of basic research received the most funds (80 per cent). During its first year of operation, the foundation received 500 proposals and made 150 grants. In 1993 a Kazakh Academy of Engineering and an Agricultural Academy were also established.

Most fundamental research was and still is carried out by the Kazakh Academy of Sciences, which in 1994 comprised 32 research institutes and a professional scientific staff

[11] *Alma-Ata. Nauka Sovetskogo Kazakhstana, 1920–1960*, 1960.

(i.e. holding advanced degrees) of over 4,000. Recently the government has ordered the establishment of 7 national scientific centres in the areas of space exploration, radio-electronics, ecology, computer engineering, biotechnology, and composite processing of materials. The centres will receive priority government funding. The Kazakhstan nuclear centre is already being organized, and will focus on research in radioactive pollution problems and the development of nuclear technologies and atomic power engineering.

The academy has issued a journal since January 1995, *Reports of the National Academy of Sciences, Republic of Kazakhstan*, which publishes original scientific articles by Kazakh scientists in both English and Russian. In addition to fundamental research, the academy has been actively involved in addressing the country's Soviet legacy of serious environmental problems. These include: high levels of nuclear contamination, a result of 30 years of nuclear testing; the reduction of the Aral Sea to one third of its original volume; ecological damage along the Caspian Sea; extensive air pollution, due to opencast coalmines and energy-producing plants; and erosion and desertification of virgin lands due to overgrazing. The Ministry of Education funds the scientific work of government environmental programmes on the Aral and Caspian seas with international assistance.

Most applied research is carried out at universities and other institutes of higher education, for example, the National State University and the Polytechnic Institute. These institutes have their own research laboratories and science councils to evaluate scientific dissertations. Many research topics are determined and funded through economic agreements with industrial enterprises. According to the Ministry of Education, in the past, about 20 per cent of the research institutes and institutes of higher education were funded through agreements with the military-industrial complex. Currently, the Academy of Sciences determines the funding of research and development projects on the basis of the formulation of Target Scientific-Technical Programme (TSTP).[12]

According to the Academy of Sciences, there are about 300 science and technology organizations in the country and some 30,000 technical specialists, including scientists and engineers with advanced degrees. About one third of this technical workforce is employed in Academy of Sciences institutes. Although there does not seem to be a major brain drain to foreign countries, there is however an outflow to commercial enterprises because they offer much higher salaries. In 1990 about 1 million ethnic Germans, mostly farmers, lived in Kazakhstan of whom only 170,000 now remain. The government has conducted a media campaign in Germany to persuade them to return. Also, 1.6 million ethnic Russians, 300,000 Ukrainians and 70,000 Tatars left Kazakhstan in the 1990s.[13]

[12] Erjanov and Morozov, 1996, pp. 97–105.
[13] *The Economist*, 15 April 2000.

Since 1992 the academy has actively pursued new international ties. As a result, Kazakhstan is receiving substantial amounts of Western technical assistance, in particular from the European Community in the areas of telecommunications, sector restructuring, energy conservation and environmental policies.

Kyrgyzstan

Kyrgyzstan's economy was traditionally based on nomadic herding. Even under Russian tsarist rule there was no major change in this situation. Social indicators, except those for the incidence of disease and mortality, were low. With the Sovietization of Kyrgyz society the level of education rose. The country's economy still remained agricultural in nature, although the establishment of a large number of plants of the defence industry and related research institutes changed the nature of society. As a result social indicators rose, except for mortality and incidence of disease, which declined.

A branch of the USSR Academy of Sciences was established in 1943 in Frunze (now Bishkek). This was the result of the wartime evacuation to the Kyrgyz Republic of many well-known Soviet scientists (including many members of the USSR Academy of Sciences). In 1954 the Kyrgyz branch was elevated to the status of the Academy of Sciences of the Kyrgyz SSR. At that time it consisted of 6 institutes and 500 science and technology staff. Although Kyrgyzstan was mainly an agricultural country, the economy of the Kyrgyz Republic was 80 per cent dependent on the Soviet military-industrial complex. At the time of independence in 1991, some 800,000 Russians and other Russian-speaking minorities were living in Kyrgyzstan, and many of the leading academicians were found among this group. Geophysics and geology were key research areas, given the country's mountainous terrain. In mathematics, Kyrgyzstan traditionally had the best school in Central Asia in topology, and was also strong in physics (nuclear, optical, laser and space) given its links to the defence industry. At independence, Kyrgyzstan therefore boasted a strong science and technology base, including numerous research institutes of the Academy of Sciences and a network of branch institutes, which primarily served the Soviet military-industrial complex.[14]

Because of its dependence on the Soviet Union (industry, science and technology funding), the break-up of the USSR had serious economic consequences for Kyrgyzstan. During the Soviet period, the Kyrgyz Academy of Sciences had received its primary financial support from the USSR Academy of Sciences budget. This contribution now stopped, which had a negative effect on the scope of research programmes. For despite the national

[14] Akaev (ed.), 1990.

government's officially declared policy of support for science, financial support was symbolic, being barely enough to pay the salaries. Furthermore, having been dominated in the past by the Soviet science structure, Kyrgyzstan lacked a strong centralized body to carry out national science policy in the pure and applied sciences, as well as in higher education. There was no consensus among the Academy of Sciences, the universities (new and old) and the government about the direction that scientific reform should take. Non-scientific factors, such as families and clans, cultural attitudes, regional interests and other private ties have also had a noticeable effect on the development of science policy in the country since independence.

In 1992 the president of the republic, a former president of the Academy of Sciences (1988–90), created the Committee for Science and New Technologies to implement, coordinate and fund national science and technology policy, including the Academy of Sciences. The Kyrgyz Government charged the State Agency on Science and Intellectual Property with the implementation of state technological policy. In 1993 Kyrgyzstan further adopted a new Education Law, which included changes relating to the management of the science and technology sector. One of the main goals of the Ministry of Education is to integrate higher education and scientific research. Therefore, the Committee for Science and New Technologies, formed in 1992, was brought under the auspices of the ministry in April 1995. The ministry only supports research at higher education institutions and branch institutes, as since 1994 the National Academy of Sciences has received its budget separately from the government.

In December 1993 the Academy of Sciences of the Kyrgyz Republic became the National Academy of Sciences of Kyrgyzstan. Since independence, the paradoxical situation had arisen in which the number of academy institutes had increased, but the overall numbers of science and technology staff had decreased (due to e migration to Russia, low salaries and other factors). Therefore, in 1994 it was decided to reduce the number of science and technology institutions. The scientific science and technology potential of Kyrgyzstan is concentrated in 90 independent technological entities, organizations, firms, higher education institutions, research-and-production centres and temporary creative collectives. The most important science, development and technology priorities are: health and the environment; agriculture and consumer goods; power engineering; mining and water; telecommunications; housing construction; manufacturing know-how; tourism; and basic research.[15]

To give expression to the government's desire to prioritize science, parliament adopted its first Law on Science and Principles of Government Science and Technology Policy on 15 April 1995. The law outlines government regulations for science and technology

[15] http://www.bit.ac.at/centralasia/en/china/cont_foerderung.html.

policy, describes the science structure, and sources of financing for science. These financial sources include: the establishment of a National Science Foundation of the Kyrgyz Republic, a Central Foundation for Science and Technology (not funded from the government budget), a Government Innovation Fund, and Regional and Branch Funds although the majority of these foundations have not yet been formally established. According to the law, the science and technology sector is to receive up to 3 per cent of the national budget, which is not a realistic figure. For although science and technology ranks high in the government's policy, science is not considered to be a high priority for funding, considering the demands from other sectors of the economy. GERD has dropped from 0.26 per cent in 1994 to 0.2 per cent in 1997. Most (63.5 per cent) of the funding in 1997 came from government; what was new was that industry and foreign sources (8.5 per cent) had become a structural part of research and development funding, according to UNESCO. International cooperation in science, engineering and innovative know-how is one of the main activities of the state agency on science and intellectual property. During the last 10 years, Kyrgyzstan has concluded agreements in the field of technological cooperation with all CIS (Commonwealth of Independent States) countries, the USA and the European Union.

Another unresolved problem is the brain drain. Since 1991 a majority of the Russian and other peoples who were deported during the Second World War have left Kyrgyzstan. Thousands of people are continuing to leave the country, an outflow that is worrying Kyrgyz officials because the exodus is generally among the most educated sectors of the population, initially of Russians and other non-Kyrgyz, but now also of educated Kyrgyz.[16]

Mongolia

Mongolia's feudal system was based on a hierarchy of all-embracing subservience of the large majority of the pastoral population to their hereditary overlords. There was very limited formal education and such social mobility as existed only took place within the monasteries of Tibetan Buddhism and Lamaism. Mongolia's first centre of modern sciences came into being in 1921 when the government of the newly independent nation established an Institute of Literature and Scripts. It initially employed 8 persons, among whom were a few Russians, and it also performed tasks as a branch of government. Although its main task was to translate foreign scientific and political books and articles, it was also expected to constitute a library of the same literature in Mongolian, collect old books and make an inventory of old monuments. The institute had a small budget of only 3,000 *lian*s, and was initially housed in its president's yurt. In 1922 it bought a wooden house, while its archives

[16] http://www.eurasianet.org/resource/kyrgyzstan/hypermail/200103/0040.html.

were kept in a two-storey house as of 1932. In January 1924 the institute was merged with the Department of Education and put in charge of the country's education system.

In November 1924, however, the institute's independence was restored and in 1927 it was upgraded to become the Institute of Sciences. It then also became affiliated with the system of the Soviet Academy of Sciences and was led by USSR academicians. Over time it acquired additional tasks. To the Language and Culture Sector (1921) were added the Sector for Geography and Library (1924), the State Archives (1927), the Museum of the Revolution (1931), the Sector for Animal Husbandry (1943), the Suche-Bator Museum and the Sector for Marxism-Leninism (1945). Each sector had between two and three collaborators. Due to the lack of educated people, members of the pre-revolutionary bureaucracy were initially employed. As of 1927, young students were sent abroad (France, Russia) to be educated. By 1925, the institute had already collected 6,000 books and manuscripts, among which were the Buddhist book of canonical law, *Ganshur* (108 volumes), and a commentary, *Danshsur* (225 volumes). The institute also published a series of booklets to promote the spread of scientific notions in the fields of science, geography and socio-economics, but above all on political matters.

Mongolia could not develop its capacity in all the sciences and thus focused on animal husbandry, the country's economic mainstay. The Committee for Science and High Schools (established on 5 July 1957) prepared the ground for the creation of the Academy of Sciences (24 May 1961). But the Mongolian side insisted on continued cooperation with the USSR Academy of Sciences, which also assisted in the discussions on the preparation of the next five-year plan for the development of science and technology in Mongolia. In 1961 the institute was reorganized as the Mongolian Academy of Sciences (MAS). Slowly, other sciences were added such as the institutes of chemistry and physics (1964), geology (1966), biology (1969), geography and social sciences (1971) and botany (1974). This was the result of the 1964 party congress that had stressed the need to develop capacity in these areas. Soviet Russian scientists laid the foundations in each field of science and technology.

Having transformed a country with a largely illiterate population into one with a functional scientific infrastructure, in 1975 the party created a Committee for Science and Technology charged with the implementation of its science and technology policy. A total of 13 institutes (8 of the natural sciences, 5 of the social sciences) were created as well as 30 research institutes, laboratories and other scientific establishments. As a result of the economic development of Mongolia, science received better material support so that between 1956 and 1996 the scientific staff increased by a factor of 10. Annually some 1,000 students and budding scientists were educated abroad (in Russia or Soviet-controlled East European countries), in addition to the large numbers educated in Mongolia itself.

Despite the early emphasis on animal husbandry, the focus in scientific research has now changed. Social sciences have overtaken all other sciences and agriculture has become the least important of the scientific subjects. The Mongolian Academy of Sciences currently supervises the operation of 16 research institutes and centres and Ulaanbaatar University. Furthermore, it jointly supervises 9 research and production corporations. The State Committee for Science and Technology was created on 17 September 1971 to better manage the increased number of branch institutes and the rapidly growing contacts with foreign countries. It was renamed the State Committee for Science and Technology and High Schools in 1988, while it was transformed into the Ministry of Science and Education in 1992.

Scientific work in Mongolia had traditionally reflected the country's particular geological and climatic conditions, and it involved a good deal of surveying, mapping, and cataloguing of minerals, soils, plants and local microclimates. Projects with clear economic applications were favoured. The Institute of Geography and Permafrost compiled maps of permafrost, which covers more than half the country, and devised methods of construction and mining in permafrost areas. Geological mapping and prospecting for useful minerals had a high priority. The country's climate and location make it a good place for astronomical observatories and for studies of seismicity and tectonic processes. Mongolian physicists concentrated on the development of solar energy and the photovoltaic generation of electricity to serve the dispersed and mobile herders and to help stem the flow of the population to the cities. The expansion of scientific education and of the number of scientists contributed to concern over the environmental consequences of the single-minded focus on short-term economic growth that had characterized the period from the 1960s up to the late 1980s.

The number of scientific staff has grown significantly in Mongolia during recent decades, in particular between 1970 and 1980, when the number doubled. In 1970 only 17 persons per 1,000 inhabitants worked in science and technology, while in 1980 this number had grown to 35. Given the slow buildup of scientific capacity, the composition of scientific staff represents a pyramid form, with the lowest number in the above-50 age group (11.7 per cent), followed by the above-40 age group (19.5 per cent), while both younger age groups show high numbers: the above-30 age group (31.0 per cent) and the below-30 age group (37.8 per cent) in 1985. However, when compared to 1975, there is a clear trend towards a reduction in the wide gap between the age groups, although it will take time.[17]

Prior to the passage of the 1991 Education Law, a number of ministries were responsible for the management of the education sector, but they did not formulate policy; they only implemented the decisions taken by the party. In 1992 the Ministry of Science, Technology,

[17] Sedjav, 2000, pp. 68–70.

Education and Culture (MOSTEC) was established, and all science and educational activities were subsequently placed under MOSTEC. Its scope of activities now includes policy formulation, analysis, educational planning and educational development (programme approval, staff development, institutional accreditation, and accountability for the maintenance of academic standards). Since then, the Education Law has been amended five times, the last time in 2000. Despite the changes, implementation suffers from a lack of resources that has led to a deterioration in the quality of facilities and staff (due to the brain drain) as well as cumbersome bureaucratic practices, corruption and overall inequalities. Some institutes are better (or better at selling their services) than others and thus have more funds, while poor students cannot afford the fees and thus access to education and research and development has become increasingly inequitable.

In 1997 the government reorganized about 100 scientific organizations into 20 scientific institutions and centres and 8 corporations for scientific research. The National Council for Science and Technology was established and directives on the ordering and financing of research projects were approved. The Law on Science, the Law on Transferring Technology and the paper on policy towards science and technology were discussed in parliament. The new regulations have changed the basis on which research and development is undertaken. In the past all research and development was done in state institutions (the academy, ministries, affiliated institutes, university laboratories), but now this system has been structurally transformed. It is the first attempt by the government to match needs with capacities as well as to increase research and development by industry.

The number of people in research and development had been on the rise until 1990. Thereafter, due to the political changes, working conditions, salary levels, and changes of functions, the number of people working in research and development institutes dropped by 50 per cent. Nevertheless, the number of people with a university degree continues to increase, but fewer pursue a career path via the academy and its affiliations. The number of scientists in technical sciences is growing, while the number in agriculture and medicine is not, because priority is given to technical sciences and fewer students are trained in the other fields. This is also because the government now demands result-based research and development, while under the old conditions there was a low use of science and technology despite the high cost of creating such knowledge. In the former socialist system, the material basis for scientific research was mostly dependent on grants from other countries. Because the Agricultural and Technical Universities produce most of the concrete and necessary results, they receive increased amounts from the state's budget.

The government attaches great importance to the equipment of research and development institutes to be able to work at world-class level, and to that end it aims to establish technology parks as exist elsewhere in the world. Since 1997 the objective of research and development policy has changed. Projects now have to compete for funds and are evaluated according to their relevance to the country's socio-economic problems and whether they also address issues of international importance to increase the chance of international cooperation. This demand for more accountability and relevance was spurred by the limited available GERD, which in 1997 had dropped to 0.2 per cent.

Continuing the collaborative ties that already existed between Mongolia and the Soviet Union as well as the socialist countries, similar relations have been established with West European countries as well as with the USA, Japan and the Republic of Korea. The training of Mongolian students in those countries began in 1990, and by 1994 the country had some 1,400 students abroad. Many foreign students are also studying in Mongolia. The government intends to further strengthen international cooperation in the field of science and technology to facilitate the transfer of technology and to strengthen the material basis of research in the country.[18]

North India

For the purposes of this chapter, North India is understood to include Jammu and Kashmir State and Punjab State. Both were part of British India and they were mainly agricultural economies. Education was limited, and mostly traditional in nature, whether Muslim, Hindu or Sikh, the major religions of North India. The exception was British education, which was available only to a small number of Indians after 1860. Thus Western education and techniques of scientific inquiry were added to the already established Indian base, making way for later developments. The first university in India was founded in Calcutta in 1857. In 1900 there were 5 universities; by 1920, there were 7; by 1930, 10 more had been added. By 1947, when India gained independence, there were 25 universities. Today the country has well over 300 universities and university-type institutions.

The main result of these developments was the establishment of a large educational infrastructure. Research and development, despite some isolated but remarkable individual achievements (C. V. Raman, Rajendra Nath Mukerjee, Satyendranath Bose, etc.), hardly existed before independence. In 1947 education was therefore chosen to be the principal instrument for the country's transformation from a poor, dependent, economically and technologically backward imperial colony into an advanced nation. Science and

[18] Sedjav, 2000.

technology was to bring the means for economic development, independence and equality, both externally and internally.[19]

It is therefore not surprising that the Government of India (both federal and state) has dominated the development of science and technology policy and research, mainly based on the pre-existent British pattern. This has meant a top-down approach and a large number of central ministries, institutions and organizations. In fact, the prime minister (as chairperson) controls all science and technology activities in India through the National Council on Science and Technology as well as through the prime minister's science adviser, the minister of state for science and technology (who has control over day-to-day operations of the science and technology infrastructure), and those ministers who have significant science and technology components in their portfolios.

The rest of the infrastructure has seven major components. The national-level component includes government organizations that provide hands-on research and development, such as the ministries of atomic energy and space, the Council of Scientific and Industrial Research (CSIR – a component of the Ministry of Science and Technology) and the Indian Council of Agricultural Research. The second component, organizations that support research and development, includes the departments or ministries of biotechnology, nonconventional energy sources, ocean development, and science and technology. The third-echelon component includes state government research and development agencies, which are usually involved with agriculture, animal husbandry, irrigation, public health and so on, and which are also part of the national infrastructure.

Despite the importance that the Government of India attaches to science and technology, research and development expenditures were only just over 0.7 per cent of GNP in fiscal year 1994, down from 8.6 per cent in 1986. This shows that expenditures for science and technology did not keep pace with GNP growth. Although research and development budget allocations have grown from a low 5 per cent in 1980 to 7.3 per cent in 1987, there was a decline thereafter and the figure continues to hover around 7.5 per cent. More noteworthy is the fact that most government research and development expenditures (80 per cent in fiscal year 1992) went to only five agencies: the Defence Research and Development Organization (DRDO), the Ministry of Space, the Indian Council of Agricultural Research, the Ministry of Atomic Energy, the CSIR and their constituent organizations.

Because of the allocation of financial inputs, India has been more successful at promoting security-oriented and large-scale scientific endeavours, such as space and nuclear science programmes, than at promoting industrial technology, although the Green Revolution is a noteworthy exception. Part of this lack of achievement has been attributed to the

[19] Macleod and Kumar (eds.), 1995.

limited role of universities in the research and development system. Instead, India has concentrated on government-sponsored specialized institutes and provided minimal funding to university research programmes. The low funding level has encouraged university scientists to find jobs in the more liberally funded public-sector national laboratories. Moreover, private industry in India plays a relatively minor role in the science and technology system (15 per cent of the funding).[20]

JAMMU AND KASHMIR

After independence and the partition of British India into India and Pakistan in 1947, Jammu and Kashmir was also partitioned, as the two new states could not agree on another solution, a situation that persists to this day. The science and technology agenda was mainly set in New Delhi until 1989, when a Jammu and Kashmir State Council for Science and Technology was created. Its objectives are: to popularize and disseminate science and technology in the state, with special emphasis on rural and backward areas; to promote and encourage the use of new and appropriate technologies; to sponsor programmes and projects at state research and development institutions for the socio-economic improvement of the state; to identify various problems in diverse fields and to strive for their scientific solutions; to encourage the scientific community within the state by way of awards, scholarships, fellowships and sponsorship to international conferences, seminars, workshops, etc.; and to develop scientific infrastructure and personnel in the academic and scientific institution of the state.

The Jammu and Kashmir Government funds the Science and Technology Council as does the Department of Science and Technology, Government of India, which also provides project-based funding. Some 57.6 million rupees (Rs.) were earmarked for 2003 for science and technology and environment by the state government out of a total budget of 22,651.5 million Rs. There were of course other research and development items in the budget such as agricultural research, which was five times higher (271.2 million Rs.). Some of the Science and Technology Council's success stories include: the establishment of a Genetic Counselling Centre where genetic counselling is provided for mentally retarded children and their parents; the regeneration of threatened and endangered plant species and the establishment of conservatories for ex-site conservation of plant germ plasm; and sericulture from leaf to cloth technology where, under the overall heading of training in mulberry cultivation, silkworm rearing, silk reeling, spinning and weaving are taught under one roof. These projects are implemented in collaboration with Jammu and

[20] Kuppuram and Kumudamani (eds.), 1990.

Kashmir University and specialized research institutes. Furthermore, science popularization programmes are operational throughout the state, including events such as the demonstration of a portable planetarium, the organization of science quizzes, debates, seminars and science model exhibitions, the celebration of National Science Day/Week, and demonstrations of explaining miracles, etc.

Appropriate technologies have also been popularized.[21] As an example of the latter, in December 2002 it was announced that the Department of Science and Technology would install 5,000 solar devices in 194 villages throughout the state during 2003. The Government of India further announced in 2003 that it intended to establish 139 Community Information Centres (CICs) connecting all villages across Indian-administered Kashmir, alongside call centres and other schemes to boost Information Technology (IT), even though both power and connectivity remain elusive here. The project aims to connect up the state's 2,681 villages. The latest addition to the scientific infrastructure of Jammu and Kashmir is the construction of the Indian Astronomical Observatory in the village of Hanle; sitting 4,517 m above sea level, it is the world's highest astronomical observatory.

PUNJAB

In 1983 the State Government of Punjab also created a State Council for Science and Technology, which functions under the aegis of the Punjab Department of Science, Technology, Environment and Non-Conventional Energy. Its purpose is to promote socio-economic change and environmental awareness through the application of science and technology and to bring science and technology out of the laboratories and into the life of ordinary people. The council has focused its activities on five key areas: popularization of science; environment; biotechnology; construction and building material technology; and water regime management. Each key area finances a project and monitors its progress at various stages. The State Government of Punjab funds the council as its overseer, the Department of Science and Technology, while the Government of India also provides project-based supports.

As is the case at the national level, the state's chief minister controls science and technology activities in Punjab, for the minister is ex-officio chair of the State Council. Moreover, the secretary to the Government of Punjab, Department of Science, Technology and Environment, is the chair of the Executive Committee and also the member secretary of the State Council. The Executive Committee is responsible for the management and administration of its affairs and the finances of the State Council. The council is funded by the Department of Science and Technology, the Government of Punjab, the Government of

[21] http://www.dst-sntcouncils.org/j.k/.

India and voluntary organizations like the Small Industries Development Bank of India (SIDBI). To indicate the importance it attaches to science and technology, the Government of Punjab increased its allocations for scientific research to Rs. 30.583 million for 1999–2000, and to Rs. 11.6 million for ecology and environmental studies. The State Council also generates revenue through consultancies.

The science and technology infrastructure of Jammu and Kashmir and Punjab is an integral part of the All-India science and technology system, which has grown from about Rs. 10 million in 1947 to about Rs. 30 billion in 2000, which is still less than 1 per cent of GNP. This has resulted in major achievements in such fields as agriculture, telecommunications, health care and nuclear energy. Nevertheless, large parts of India's population still face malnutrition, depend on bullock carts for transportation, suffer from diseases that have been eradicated in many other nations, and use cow dung and wood for fuel. Although the government has decentralized to some extent, central government control over the planning and operation of research institutions continues, and the weak link between the research and industrial sectors persists. However, because of its large number of domestic- and foreign-trained scientists and engineers and its extensive participation in the scientific programmes of leading industries, India has the capacity to deal with and overcome these problems.

Pakistan

What is now Pakistan had the same history of inadequate science and technology infrastructure prior to independence as India (with which it had constituted British India until 1947). Consequently, the development of scientific education and research in the modern sense is of comparatively recent origin in Pakistan. In 1947, before independence, there was only Punjab University, which had been established in 1882. For a long time it was an affiliating and examining body; most of the teaching work was done in affiliated colleges scattered over the whole province of the British Indian province of Punjab and administered and maintained either by the provincial government or by private philanthropic societies. Academic control over these colleges was vested in the university, which prescribed the courses and syllabuses, conducted the examinations and conferred the degrees. It is clear that this sole institution could not possibly provide the science and technology needs of a nation of some 20 million people.

After independence, the Pakistan Academy of Sciences (PAS) was established in 1953 to promote science and technology, disseminate scientific knowledge and honour eminent scientists, primarily through their election as fellows. In addition to having exchange programmes with scientific societies, academies and learned bodies in several countries, the academy also publishes a scientific journal (since 1960) and monographs on topics of national interest. It also arranges seminars, symposia, conferences and workshops at national and international levels.[22] The Pakistan Council for Science and Technology (PCST) was established in 1961 as the National Science Council of Pakistan (it changed to its present name in 1984) on the recommendation of the first National Science Commission, which met in 1960.

The government has created a separate Ministry of Science and Technology (MoST), whose task is to guide, manage, coordinate and promote all science and technology issues. The Pakistan Council of Science and Technology (PCST) supports the ministry in an advisory role on all science and technology policies and programmes, and suggests measures for the promotion, development and application of science and technology in the country. As such, PCST reviews the work of research and development institutions, etc. Another organization is the Pakistan Science Foundation (PSF), created in 1973, which finances research and development agencies and promotes basic or fundamental research that relates to the country's socio-economic needs.

In 1984 MoST formulated Pakistan's National Science and Technology Policy, which argued the need to attach greater importance to science in national development and that government should take the lead in this. The government approved the science and technology policy and its Action Plan, which among other things required the creation of a National Commission for Science and Technology (NCST) as the major decision-making and coordinating agency, to be headed by the prime minister. MoST would act as the Secretariat of NCST, while it retained the task of formulating science and technology policies and programmes. The new structure means that all research and development organizations that function under different federal ministries and provincial departments are engaged in scientific and technological research and development activities.

PCST, in consultation with the federal ministries and provincial departments, major research and development organizations and universities, eminent scientists and technologists, and representatives of the industrial sector, plans for civilian science and technology and research and development activities in the country. These plans are reviewed by the Executive Committee of the National Commission for Science and Technology (ECNCST) before they are presented to NCST for approval. In 1984 the government also established the National Centre for Technology Transfer (NCTT). Its major functions are to act as a clearing-house for technologies (local and foreign), to disseminate information, to support institutions in research and other activities related to technology transfer, to organize

[22] Siddiqi, 1979.

seminars, etc., and to carry out activities to develop personnel in technology transfer and other related areas.[23]

Science and technology research work is largely carried out in autonomous or semi-autonomous organizations administratively linked with various federal ministries. The research and development organizations operating in the public sector may be classified in terms of areas of specialization, e.g. food and agriculture, industry, water, etc., or on the basis of administrative control by federal ministries. Presently, the number of research and development organizations functioning at the federal level is 58. These organizations function under 12 ministries and 2 divisions, and their activities range from primary research to database formation and information dissemination. Apart from these organizations operating at the federal level, a number of organizations exit at provincial level. However, these organizations work with organizations at the federal level and as such their programmes are mostly common in nature.

There are furthermore science and technology institutes and field stations (non-autonomous) attached to the federal and provincial governments, e.g. Pakistan Industrial Technical Assistance Centre (PITAC), Provincial Agricultural Research Institutes and Rice Research Institutes, etc. The Pakistan Council for Scientific and Industrial Research (PCSIR), established in 1953, is the country's largest research organization. Its objectives include systematic evaluation, development, value addition, and utilization of indigenous raw materials. It also conducts applied research and development work on problems being faced by the industrial sector with a view to adapting, modifying and improving existing technologies appropriate to local conditions. Other major research and development organizations include the Pakistan Atomic Energy Commission, the Defence Science and Technology Organization (DESTO) and the Pakistan Space and Upper Atmosphere Research Commission (SUPARCO), the national space agency.[24]

Despite the country's impressive science and technology infrastructure, critics find that it still falls short of what is required. In an essay on 'Ideological Problems of Science in Pakistan', the Pakistani physicist Professor Pervez Hoodbhoy presents a graphic picture of the collapse of attempts made in the 1960s and 1970s to build a science base in Pakistan. By the 1980s, the best scientists had left or been dismissed, few young scientists were being trained, and above all, the proponents of so-called 'Islamic science', who claim that the Qur'an contains all possible science, had acquired positions of power in educational and research and development institutions. Hoodbhoy concludes:

[23] Abdur Rahman, Quereshi et al. (eds.), 1990.
[24] *Science and Technology Manpower Development in Pakistan: A Critical Appraisal*, 1985.

> Indeed, the reaction against science as an instrument of reason, whether applied to social matters or even natural phenomena, appears to intensify with increasing technological dependence on the West ... The import of technology makes possible the simultaneous coexistence of mediaevalism with the space age.

Because of the allocation of financial inputs, Pakistan has focused on and been successful at promoting security-oriented, space and nuclear programmes rather than developing cutting-edge science or industrial technology. This has been encouraged by the fact that all research is funded by the state. There has been very little university or industry-related focus on research and development. As one Pakistani scientist put it:

> Making bombs and missiles has indeed demonstrated a high level of engineering and management skills, but these programmes have little to do with cutting-edge science, original scientific research, high-technology, or the country's general scientific progress.

According to Atta-ur-Rahman, Pakistan's leading chemist and minister of science and technology in 2000, during the period 1990–4 Pakistani physicists, chemists and mathematicians produced only 0.11 per cent, 0.13 per cent and 0.05 per cent respectively of the world's research publications. Pakistan's total share of world research output in 1994 was just 0.08 per cent. The average number of citations per paper was around 0.3. In other words, an overwhelming majority of papers by Pakistani scientists had zero impact on their field. Furthermore, the value-added component of Pakistani manufacturing somewhat exceeds that of Bangladesh and Sudan, but is far below that of India, Turkey and Indonesia. Finally, the country's education system needs a thorough overhaul and with creeping ' Talibanization', the dawn of scientific enlightenment among the masses recedes daily.[25]

The opinion of these scientists is not shared by the government, however, which at the United Nations Second Committee on Science and Technology for Development (16 October 2002) declared that science and technology formed an important component of Pakistan's development strategy. To that end, the Government of Pakistan had adopted a holistic, progressive and participatory approach to its promotion:

> Our IT vibrant policy is aimed at the development of an extensive pool of skilled IT work force; designing of legislative and regulatory frameworks; providing business incentives for investors; and the establishment of an efficient and cost-effective infrastructure that provides affordable and wide-spread connectivity. Significant steps have been taken to ensure that digital gap is rapidly narrowed.

Given the importance that the Government of Pakistan attaches to science and technology research, it has over the last two decades increased development expenditures. These were 0.77 per cent of GNP in fiscal year 1981, but have steadily risen since then to 0.92 per

[25] www.alephinc.net/pakistan/html/article2.htm; Rahman, n.d.

cent in 1987. Atta-ur-Rahman, when he was briefly minister of science and technology in 2000, convinced his government that appropriate funding for science and technology could produce valuable long-term dividends for economic development. As a result, the government's proposed budget for science and technology was increased from US$2.2 million in 2000 to US$300 million in 2001– an astonishing increase that brings Pakistan's expenditures for science and technology to 0.5 per cent of its GDP.[26]

Tajikistan

'Science, as we understand it today, appeared in Tajikistan only in Soviet times,' according to Academician Rajabov. Indeed, the country had little scientific capacity in the nineteenth century. In this agricultural economy, the role of women was severely restricted, and in some regions they hardly ever left their homes to work elsewhere, even in the fields. Tajikistan became the object of many scientific studies only after a Soviet state had been established. These studies, carried out by Russian scholars, focused on the country's mineral wealth, flora, fauna, agriculture and public health. It was on the basis of these studies that industrial and hydro-power projects were built and that the programme for the development of Tajik agriculture was drawn up. In the 1920s the Society for Studying Tajikistan and the Iranian Ethnic Groups beyond its Borders, with its various branches, was established in Dushanbe, Khorog, Samarkand and Bukhara. The society arranged scientific expeditions and organized meetings to discuss scientific papers on Tajikistan. The institute also served as a counterbalance to Pan-Turkism, which held that Tajiks were only Iranized Turks. These activities had some impact on the establishment of an autonomous, and then a union Soviet republic.

The Agricultural Experimental Station, established in 1927 near Dushanbe, was one of the first scientific institutions in Tajikistan. In January 1930 the Central Executive Council of the Tajik SSR was established. Its tasks were: first, to plan all scientific work conducted by various organizations on the territory of the Tajik SSR; and, second, to make a comprehensive scientific study of Soviet Tajikistan and the neighbouring countries of the Soviet and Foreign East in respect of their natural wealth and productive forces, economy, social movements, language, law, state development, etc., as well as the development and improvement of the subjects laying the theoretical groundwork for such a study.

Russian interest in the development of Tajikistan led to the establishment of a special committee of the USSR Academy of Sciences. Its aims were: to promote the organization of local scientific and research work; to provide methodological guidance for local

[26] http://www.ictp.trieste.it/~sci_info/News_from_ICTP/News_94/features_Pakistan.html.

studies of the productive forces; and to directly tackle problems raised by the government in accordance with the plan. The USSR academy was therefore the first body to organize scientific research in Tajikistan. As a result, by the end of 1932, Tajikistan already had 13 scientific institutions. In 1933 the Kara-Mazar Scientific Research Institute was created, while the National Astronomical Observatory was established in 1932. Hundreds of Tajiks also received an education in Russia. To bring order to the rapidly growing amount of scientific data, the USSR academy opened a base in Dushanbe in January 1933. It had sectors dealing with geology, botany, zoology, parasitology, pedology and the humanities.

Tajikistan's industrial development began in the late 1930s. The early emphasis had been on processing cotton and manufacturing construction materials. The Second World War, however, was a major stimulus to industrial expansion. The output of existing factories was increased to meet wartime demands, and some factories were moved to the republic from the European part of the Soviet Union to safeguard them from the advancing German army. Skilled workers who relocated to Tajikistan from points west received preferential treatment, including substantially higher wages than those paid to Tajiks; this practice continued long after the war. Such migrants provided the bulk of the labour force in many of the republic's industries up to the end of the Soviet era. Cotton textile mills and metallurgy, machine construction, the aluminum smelting plant and the chemical industry all had disproportionately small percentages of Tajik workers, or none at all.

Given these new developments, demand for more research also grew. In 1940, therefore, the Tajik base of the USSR Academy of Sciences was transformed into the Tajik branch. The Astronomical Observatory, the Vakhsh Soil Institute and some smaller establishments were also incorporated into the branch. Other institutions were later created for such research fields as stockbreeding (1944), and chemistry (1945), and a Sector of Geophysics (1946). The branch also trained many local scientists: in 1951 there were 150 scientists working there. On 14 April 1951 the Academy of Sciences of the Tajik SSR was created.[27]

Before independence, the State Committee of the USSR for Science and Technology implemented programme-targeted planning and defined programmes of union significance. Research institutes were financed by the state budget and by self-financed contracts that constituted more than 98 per cent of total expenditures for science; only 1.2 per cent came from non-centralized sources.[28] The focus of research and development was on the country's rich deposits of minerals and ores important to the mining, oil, gas and coal industries; hydroelectric energy resources; geophysical seismological conditions of Tajikistan;

[27] Rajabov, 1998
[28] http://www.undp.org/rbec/nhdr/1996/tajikistan/chapter12.htm.

agricultural conditions; and high birth rates and problems of basic health care. The stable growth of research in terms of personnel, materials, technology and financial support was obvious in the republic before the 1990s. There were more than 100 research or scientific establishments. There were also 400 units with various laboratories, projects and experiments. However, the civil war inflicted great damage and many units were destroyed or plundered.

After independence in 1991 there were no more centralized subsidies and financial support for the Academy of Sciences was drastically reduced. With few exceptions, scientific research has been and continues to be carried out under state sponsorship. The republic's Economic Reform Programme for 1995–2000 asserted that the government would elaborate a programme of support and development of scientific research with the aim of increasing the efficiency of science by regulating and coordinating research priorities. A joint commission comprising the National Academy of Sciences, the Centre for Strategic Research, the Tajik branch of the International Fund of Economic and Social Reforms and the Society of Economists of Tajikistan is charged with the elaboration of a national scientific and technological policy. However, government spending on science dropped from 2.5 per cent in 1994 to 1.5 percent in 1995.

The Republic of Tajikistan currently has 10 research academies (Agriculture, Architecture, Building, Engineering, Higher Learning, Medicine, Music, Natural Sciences, Pedagogical Sciences and Sciences). In addition, there are many branch institutes under the various government ministries. Previously, most were involved in large joint projects in cooperation with the leading institutes of the Soviet Union, but now most of the links have been severed. Each academy and institute currently finds itself responsible for seeking its own funding, apart from very limited government subsidies, to support its planned research and to increase the salary of its fellows. Therefore international cooperation and private-sector support is sought to develop the financial base of research units. Also, there is less emphasis on pure science and more attention is paid to research and development that is likely to have a practical and marketable outcome.[29]

Inflation, non-payment of salaries and the emigration of personnel have further undermined the functioning of scientific establishments. There has been a brain drain of young specialists due to the lack of current and future prospects. Instead of its 4,100 fellows in 1985, the National Academy of Sciences now has only 2,600. The loss of fellows in the natural sciences has been especially marked, and significant numbers of these specialists have emigrated permanently. The average age of acting academicians is now 62. Since the end of the 1980s, there has been a rapid decline in the numbers of graduate and

[29] http://www.tajik-gateway.org/index.phtml?lang=en&id=1536.

postgraduate students. Consequently, there is little hope that the numbers of lost specialists can be made up by new graduates. Postgraduate enrolment in 1994 was one quarter of what it was at the beginning of the 1990s and few representatives of science can go to advanced courses abroad or defend their projects for grants. At present almost all fundamental investigations are at a standstill. The Tajikistan Development Programme Report concluded that:

> The lack of funding; sharply curtailed research programmes, expeditions and fieldwork; outdated equipment; and severely limited access to scientific literature, conferences and other exchanges of knowledge may also have long-term effects upon the competencies and currency of the remaining fellows as well as on the students who work with them.[30]

Turkmenistan

The population of the khanate of Khiva was mainly nomadic in nature and was incorporated into Russia in 1881. In 1873 the Khiva khanate was conquered by the tsarist troops. Russia did little to develop its newly won territory apart from introducing cotton as a cash crop. In 1924 the communists established the Turkmen Soviet Socialist Republic (SSR) as a full member of the USSR. Gradually the Turkmen tribesmen were transformed from pastoralists into cash croppers, a process completed in the 1930s. Russification through the education system and political process transformed the nature of the country, while industrialization only took place after 1970.

Turkmenistan was an economic and science and technology backwater until recent times. In 1926 the Russian Academy of Sciences established a sector at Ashgabat that dealt with Turkmen culture. Other science and technology activities remained mainly limited to agricultural, linguistic and historical research. In 1941 the Russian Academy of Sciences established a branch at Ashgabat that mainly dealt with subjects such as history, linguistics, literature, biology and geology. In 1951 the National Academy of Sciences of Turkmenistan (NAST) was created with 10 institutes. In 1957 an additional 4 institutes were added (chemistry, botany, zoology and economics). Later other institutes were added so that by 1960 all science and technology sectors were covered by the NAST institutes. A further boost to NAST activities was given by the role of Turkmenistan as the launching pad of the Soviet space programme as well as by the development of the country's energy resources after 1970.[31] Industrialization, however, remained limited and at independence in 1991 Turkmenistan still did not have a major industrial infrastructure.

[30] for details, see http://www.undp.org/rbec/nhdr/1996/tajikistan/chapter12.htm (Tajikistan Development Report).
[31] Azimov (ed.), 1971; Melikov, 1992.

After independence the new government made structural changes in the governing structure of the country, including the science and technology sector. Saparmurat Niyazov, the president of Turkmenistan, became the central figure in the science and technology sector (as in every other sector), and he therefore closed the country's Academy of Sciences. At that time, the basic scientific institutes in Turkmenistan were the Supreme Council on Science and Engineering at the president's office in Turkmenistan (SCCE), the Academy of Sciences, the Academy of Agricultural Sciences, the Academy of Medical Sciences and the universities. On 16 February 1993 the president decided that the Supreme Council on Science and Technology at the president's office in Turkmenistan (VSNT) had the status of a state control and management institute. Henceforth, 'The decisions of the Supreme Council in the field of state scientific and technical politics are subject to obligatory performance by the ministries, departments and other organizations.' The basic tasks of VSNT are: definition of priority directions and forecasting of development of science, engineering and technology in the country; coordination of the scientific and technical programmes; target financing of fundamental and applied research; and development of international cooperation. Members of VSNT are drawn from leading scientific researchers, experts and managers of sectors of the national economy.

Fifty-three institutions of higher learning, many with productive research programmes, were active in 1993. Higher education and research was hindered, however, by a shortage of laboratories, libraries, computers and data banks, and the publishing facilities to disseminate research findings. The Government of Turkmenistan therefore adopted the Law on State Scientific and Technical Policy (on the development of science and engineering), which states that these areas should be allocated not less than 1 per cent of the national budget. VSNT distributes selected financial assets based on a system of grants that are allocated on a competitive basis. The coordination and control of performance of scientific projects are carried out with the help of six expert commissions, consisting of leading scientists.

To exercise greater control over science and technology, the president signed a decree on 15 December 1997 abolishing the Academy of Sciences and all postgraduate institutions. Researchers and scientists of the academy were henceforth responsible to the government ministries and agencies that deal with their respective specialist areas. The president said he made the decision because of the 'lack of any practical scientific results' from either the academy or the postgraduate institutions. It also resulted in the merger of several institutes as well as staff reductions. For example, the Desert Research Institute was renamed the Institute of Deserts, Flora and Fauna of the Ministry of Nature Use and Conservation of Turkmenistan. It was the result of the merger of three former institutes of the Academy of Sciences: the Desert Research Institute, Botany Institute and Zoology Institute. Of the 1,000 persons working there, only 80 were kept. According to critics of this new policy, the botanical garden was closed and transformed into the city park. Also all botanical collections have allegedly been lost. These critics believe that the same fate may befall all other scientific collections, and the scientific equipment of the former Academy of Sciences.[32]

The official science and technology policy, as determined by the president, is that, first, science in Turkmenistan is still in the making, and, second, it is based on principles of simultaneous development of fundamental and applied sciences. Scientific research in the country is conducted in 28 research institutes. The president did not want to leave to chance the determination of priorities in both basic and applied research. In basic research the authorized priorities are: the chemistry of petroleum and gas; the biological variety of flora and fauna; the Earth sciences; the transformation of renewable sources of energy; the science of ecologies; and the reconstruction of an objective history of the Turkmen people and state.

The authorized priorities in the field of applied research include: biological means of protection of plants and animals; oil and gas technology, in particular drilling at great depths; technology of forecasting, search and investigation of deposits of minerals; development of non-conventional renewable sources of energy; new materials and chemical products from local raw materials; and maintenance of a high standard of health among the population. For the period up to 2010 a new programme of research-engineering development has been elaborated. The policy of the president in this respect suggests the application of advanced technologies, and the creation and development of national technologies. The objectives to be resolved by science up to 2010 lead to the requirements of social policy, the main goal of which is the provision of high living standards.

Uzbekistan

In 1924 the Uzbek SSR, a new administrative unit, was established: it included present-day Uzbekistan and Tajikistan. In 1929 the Tajik and Uzbek Soviet socialist republics were separated. During the Second World War, many industrial plants from European Russia were evacuated to Uzbekistan and other parts of Central Asia. With the factories came a new wave of Russian and other European workers.[33] Because native Uzbeks were mostly occupied in the country's agricultural regions, the urban concentration of immigrants led to Tashkent and other large cities becoming increasingly Russified. Uzbekistan played a

[32] http://lists.isb.sdnpk.org/pipermail/eco-list-old/1998-January/000879.html.
[33] Abdullaev, 1958; Fazylov, 1959.

central role in Soviet bio-warfare research, because both anthrax and bubonic plague are endemic to the country. The biggest anthrax testing ground in the USSR was on a remote island in the Aral Sea, while Central Asia was the centre of a web of disease-research stations known as the Anti-Plague System. The State Committee of Science and Technology of the Republic of Uzbekistan was responsible for science and technology policy.

After independence in 1991, the Ministry of Higher and Secondary Specialized Education became the main coordinating body in higher education; it sets strict rules for the recognition of new developed curricula according to the state educational standards. Research was and is the domain of the Uzbekistan Academy of Sciences (UzAS). Founded in 1943, the academy currently has a membership of 155 (49 academicians and 106 corresponding members). It is the largest scientific organization in the country and includes more than 50 scientific research institutions and organizations. Its main goals are to advance fundamental scientific research closely connected to economic, industrial and cultural development, study new possibilities of technical progress and promote the practical application of scientific achievement and development.

In October 2003, on the occasion of the sixtieth anniversary of the founding of the Academy of Sciences of the Republic of Uzbekistan, the government adopted a resolution that stressed the need to create the technologies of prospecting, extracting and processing of precious metals and stones as well as the need to develop the country's modern education system, which is connected with the activity of the Academy of Sciences and its scientific establishments. It further emphasized the need for applied research and for cooperation with industry. The government further charged the corresponding organizations with establishing a special fund under the aegis of the Academy of Sciences for the development of advanced technologies and products using local materials.[34] This policy reflects the message conveyed by the new Science and Technology Research Council, which is headed by the prime minister: 'No research for the sake of research alone.' He noted that, since the restructuring of science and technology was still in progress, opportunities to learn from the experience of others were welcomed.[35] State programmes of basic research and scientific and technical development works are financed by funds from the state budget of the Republic of Uzbekistan, annually allocated by the 'Science' branch. The volume of budget financing for 2005 was designed on the basis of priority trends of science and technology, established in accordance with the priorities of the country's social and economic development.

34 http://ino.uzpak.uz/eng/scien_engin_eng/scien_engin_eng_3010.html.
35 http://www.nato.int/science-old/e/ankara.htm.

To implement this new policy, Technical-Scientific Programmes (TSPs) have been drawn up within the framework of the country's socio-economic development priorities. Their contents are determined on the basis of proposals by the Academy of Sciences and suggestions from the Academy of Agricultural Sciences and from ministries and departments responsible for science and technology. The annual budgets for the TSPs are fixed on the basis of the annual programme adopted. The latter is the task of the State Committee for Science and Technology. Copyrights of research results are held by the executing state institute on behalf of the state. The state remits part of the funds that it receives in case of the sale of scientific and technical products to the Uzbek State Committee for Science and Technology, which invests the money in innovative research and development. The idea is to provide incentives to scientists to compete with one another, so that they receive a larger share of the budget.

Through contract plans, more accountability is aimed for, while the government also uses the distribution of the research and development budget to address regional problems. This is necessary because many scientists have not yet adapted to the market orientation of the new science and technology government policy. Another constraint is the inadequate economic-legal framework in which research and development takes place as well as the inadequate use of non-budgetary resources to fund science and technology activities. The current science and technology priorities are: formulation of social and economic policy itself; agro-industrial complex; fuel and power engineering complex; mineral and feed stock complex; health care and environment; and information technologies and management. For the current decade 300 programmes have been authorized, in which more than 60 organizations and 27 TSPs participate.[36]

Xinjiang Uighur Autonomous Region

Science and technology in this region was limited to what was necessary for herding and crafts. Medical and other sciences were very rudimentary and of a folk nature rather than of a scientific bent. Given that most people were rural, the literacy rate was low (less than 1 per cent), and the capacity for and access to higher education and research was limited, tradition-bound and focused on religion and its ancillaries. As a consequence, not only was the literacy rate low, but so were all social indicators, except for the incidence of a large number of diseases and mortality, which were high. In this situation hardly any change occurred during the first part of the twentieth century.[37]

[36] Riskiev, 1996, pp. 27–33.
[37] Forbes, 1986.

It was only after the establishment of the communist state of the People's Republic of China in 1949 that institutions, policies and work methods were radically changed so that people could be educated, science and technology applied, new problems researched and new solutions developed. The fact that in the 1950s and 1960s the central government sent massive numbers of Chinese to Xinjiang to help develop water-conservancy and mineral-exploitation schemes also contributed to this change. They worked in the Xinjiang Production and Construction Corps (XPCC), established in 1954. Many of them were demobilized members of the People's Liberation Army (PLA) who had previously been engaged in the building of farms, schools and hospitals, but also of factories and mines as well as having performed defence functions. Each year, the XPCC sent groups of technicians to adjacent counties, townships and villages to give training courses in growing crops and operating and repairing farm machinery, and to spread advanced technologies. The XPCC was dissolved in 1975, but recreated in 1981 and since then it has been engaged in constructing irrigation works, sand breaks and forest belts. Because of the large influx of Han Chinese, these are now almost on a numerical par with the Uighurs, who had been 74 per cent of the population in 1953.

Because of the region's relative backwardness, the central government arranged that as of 1989 some 80 institutions of higher learning in the hinterland should enrol 10,000 university and junior college students, 640 postgraduate students for specific posts or work units, 860 teachers and education administration personnel, and 1,400 business administration personnel from among Xinjiang's ethnic minorities. In addition a number of ethnic-minority visiting scholars were sent abroad for further studies. A similar policy has been pursued with regard to Xinjiang's backward industrial enterprises. The central government decided to move some enterprises and factories from more developed areas along the south-east coast of China to Xinjiang. It further transferred engineers and technicians from the inland areas to newly established key enterprises in Xinjiang, and sent large numbers of handpicked ethnic-minority workers from Xinjiang to study and practise in advanced enterprises in the inland areas, resulting in the growth of a big contingent of leading engineers and technicians for Xinjiang in a very short period of time.

Despite the important changes that have taken place over the last half-century, Xinjiang is a region where many non-Han people are still traditionally nomadic and primarily engaged in agriculture or pastoral pursuits. Because of this nomadic lifestyle, many of the herders in Xinjiang still live in felt yurts, but their children receive free compulsory education. Consequently, whereas the economic base of Xinjiang is still agriculture, the development of modern science, farming, transportation and industry means that it does not lag far behind other Chinese provinces as it did in the past.

Since 1985 the organs of self-government in regional autonomous areas have extensive self-government rights beyond those held by other state organs at the same level. These include, among many other things, independently planning and managing science and technology matters. In addition to its own funds, the region's institutes can apply for funding to the National Natural Science Foundation of China (NSFC), which supports basic research and some applied research and assists talented researchers. The university in Urumqi is also connected to CERN, China's 'information highway' linking every part of China and every corner of the world, to improve education quality and research abilities in the country, and to provide Chinese universities and colleges with easy access to the world's science and technology.

Given the fact that science and technology is an integral part of socio-economic development in Xinjiang, its science and technology infrastructure has grown over time and currently boasts research and development institutions as well as those involved in outreach and the popularization of science and technology findings. Care has been taken that all these responded to the socio-economic needs of the region as well as to its ethnic composition. The rapid industrialization and commercialization of science and technology have changed Xinjiang's traditional ways of agricultural production and operation. In particular, progress has been made in the fields of protective plant cultivation, irrigation technology and strain improvement. The industrial base that has been created in Xinjiang has also benefited from the government's emphasis on science and technology in the development of the regional economy. As a result, it is modern, economically efficient and cost-competitive.

Currently, Urumqi has about 110 scientific research institutions under either the government of the autonomous region, the government of the city or various national government ministries. There are also 45 specialized societies, associations and other academic organizations. The total number employed by all these institutions is 5,000. By the end of 2001, the number of professional and technical personnel in the enterprises and institutions of the whole region had reached 385,100. Many of these institutes, such as the Xinjiang Institute of Ecology and Geography, are affiliated with the Chinese Academy of Sciences. Other major institutions include the Xinjiang Academy of Agricultural Sciences, the Xinjiang Science and Technology Committee and Xinjiang University. These and other organizations publish science and technology journals, either in Chinese or Uighur. According to government data, during the 50-odd years since the founding of communist China, Xinjiang has achieved 7,102 significant science and technology findings, of which 201 have won national awards. What is of particular interest to the region is that the technical popularization of Xinjiang's merino sheep has attained an advanced level in China, while the region's technology of desert highway construction is at the cutting edge in its field. The highway running through the Taklamakan desert, for example, is the only one in the world built on shifting sand.[38]

[38] www.chinaembassy.org.np/white_paper/xinjiang/6.htm.www.mail-archive.com/uighur-l@taklamakan.org/msg03747.html.