Science Diplomacy: Unlocking Pakistan's Potential for Regional and Global Partnership

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Abstract

Science diplomacy is increasingly recognized as an effective tool for addressing global non-traditional challenges, promoting international collaboration, and enhancing national capacities in various sectors. It involves leveraging international scientific collaboration to address global issues, enhance foreign relations, and foster scientific partnerships for national benefits. Pakistan has enormous potential to benefit from science diplomacy. The research paper examines Pakistan's existing science diplomacy-related initiatives at the bilateral and multilateral levels and also assesses key future areas of cooperation where science diplomacy can be utilized as a foreign policy tool to promote national development. By applying the theory of sustainable development, the study argues that Pakistan adheres to the United Nations' Sustainable Development Goals to promote shared economic prosperity. This qualitative study focuses on how Pakistan can leverage scientific cooperation to foster innovation and contribute to global science diplomacy initiatives. The findings of the study suggest that regional and global collaboration on joint research projects, technology sharing, and strategic investments in science diplomacy initiatives could strengthen Pakistan's image outwardly and growth inwardly.

Keywords: Science Diplomacy, Non-traditional Threats, Sustainable Development Goals, National Development, Global Partnerships, Shared Economic Growth

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Introduction

Science diplomacy has emerged as an important tool for promoting international cooperation and addressing non-traditional global challenges in an increasingly interconnected world. It involves international collaboration across diverse scientific fields to promote cooperative research and innovation, and socio-economic development among countries. Science diplomacy emphasizes that joint scientific efforts can help address global societal challenges while strengthening relations between states.[1] Following World War II, states made deliberate efforts to strengthen international cooperation in science and technology as a means to rebuild trust and support global peace, socio-economic growth, and development. As part of these efforts, two international institutions, such as the United Nations Educational, Scientific, and Cultural Organization (UNESCO) and the International Atomic Energy Agency (IAEA), emerged in 1945 in 1957,[2] respectively.

UNESCO promotes cross-border scientific research as a means to increase peace and stability. It has established networks such as the International Hydrological Programme (IHP)[3] and the International Geoscience and Geoparks Programme (IGGP), encouraging countries to share research, data, and technologies to address common issues such as water and environmental issues.[4] The IAEA's mandate focuses on the peaceful uses of nuclear technology. It provides training for capacity building in 180 countries to utilize nuclear technology for socio-economic development. Through its technical cooperation programme, the IAEA provides training, equipment, and funding to countries for peaceful nuclear applications in fields like energy, agriculture, water management, and the healthcare sector.[5] This program facilitates science diplomacy by building trust and promoting nuclear technology as a tool for development.

Apart from UNESCO and IAEA, the UN-led bodies actively advance science diplomacy across a broad spectrum of disciplines by fostering international scientific collaboration. The World Health Organization

[1] "What Is Science Diplomacy?" *The World Academy of Sciences (TWAS)*, December 11, 2023, https://twas.org/article/what-science-diplomacy
[2] "International Atomic Energy Agency, History." *International Atomic Energy Agency*, accessed December 24, 2025, https://www.iaea.org/about/overview/history
[3] "Intergovernmental Hydrological Programme." *UNESCO*, 2022, https://www.unesco.org/en/ihp
[4]"International Geoscience and Geoparks Programme." *UNESCO*, 2022.
[5] "Technical Cooperation Programme." *International Atomic Energy Agency*, https://www.iaea.org/services/technical-cooperation-programme

(WHO) plays an important role in coordinating global public health responses,[6] while the World Meteorological Organization (WMO) facilitates the systematic exchange of meteorological and climatological data essential for disaster risk management and climate policy formulation.

The World Intellectual Property Organization (WIPO), a specialized agency of the United Nations since 1974**,** plays a significant role in the framework of science diplomacy, as it provides the institutional platform for negotiating global rules on intellectual property rights that directly impact scientific research, technological innovation, and knowledge sharing.[7] By facilitating cooperation among its 193 member states, WIPO helps bridge gaps between developed and developing countries, enabling access to patents, technology transfer, and research collaboration. In this way, WIPO functions as a diplomatic platform where states reconcile national interests with global priorities, advancing both scientific progress and international cooperation.

The United Nations Environment Programme (UNEP) provides scientific assessments and policy guidance on global environmental issues.[8] The Intergovernmental Panel on Climate Change (IPCC), established by UNEP and the World Meteorological Organization (WMO), serves as a model of science diplomacy by synthesizing scientific evidence to facilitate climate negotiations under the UN Framework Convention on Climate Change (UNFCCC)**.**

The International Telecommunication Union (ITU) advances science diplomacy by enhancing global collaboration in digital technologies. Through initiatives like the "AI for Good" platform and the "Partner2Connect" coalition, ITU promotes sustainable development and bridges the digital divide. It also facilitates dialogue on key issues like AI, cybersecurity, and climate change, making it a vital player in promoting equitable access to Information and Communication Technologies (ICTs) and international cooperation.[9]

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[6] "How Science Diplomacy Can Make a Difference in Global Health." *Health Policy Watch*, March 11, 2023, https://healthpolicy-watch.news/how-science-diplomacy-can-make-a-difference-in-global-health/

[7] World Intellectual Property Organization (WIPO). "WIPO — A Brief History," https://www.wipo.int/about-wipo/en/history.html

[8] "Global Science Diplomacy for the Environment Program." *Global Council for Science and the Environment*, https://www.gcseglobal.org/GSD

[9] "ITU." *Diplo*, January 30, 2023, https://www.diplomacy.edu/itu/

Science Diplomacy

Science diplomacy has played a significant role in peacebuilding by bringing nations closer, including those with conflicting ideologies and priorities. For instance, the International Space Station (ISS) was established in 1998 as a collaborative effort among space agencies of the United States (US), Russia, Japan, Canada, and the European Union (EU) to build cooperation in space exploration and research.[10]

Science diplomacy has been essential in resolving and reducing conflicts by encouraging cooperation and trust among countries. The Synchrotron-Light for Experimental Science and Applications in the Middle East (SESAME) project is a prominent example. SESAME is a particle accelerator and research facility located in Jordan. Scientists from politically unstable and conflict-ridden nations come together and collaborate on common scientific objectives, concentrating on fields like material science, environmental studies, and medical research, despite the geopolitical rivalries between their governments.[11]

While science diplomacy often facilitates international cooperation, it can also be a source of conflict when scientific and technological advances intersect with national security, economic interests, or geopolitical rivalries. The Cold War era exemplifies how missile development, like the arms race between the US and the Soviet Union, escalated global tensions and resulted in devastating consequences. More recently, concerns over the unethical use of emerging technologies like artificial intelligence have surfaced, exemplified by fears around autonomous weapons and mass surveillance programs. These examples illustrate how science diplomacy, while being a powerful tool for collaboration, can also exacerbate conflicts when scientific progress impacts security, national interest, and ethical governance.

The research paper explores the significance of science diplomacy in Pakistan and examines how scientific collaboration can contribute to national growth and international partnerships. Pakistan has taken several initiatives at bilateral and multilateral levels to pursue science diplomacy efforts, but its potential goes far beyond the existing initiatives. Pakistan can mitigate pressing non-traditional threats while enhancing its global scientific footprint. By analyzing successful case studies from other

[10] "International Space Station." *National Aeronautics and Space Administration (NASA)*, https://www.nasa.gov/international-space-station/

[11] Smith, Chris Llewellyn. "Synchrotron Light and the Middle East: Bringing the Scientific Communities Together through SESAME." *Science & Diplomacy*, https://www.sciencediplomacy.org/perspective/2012/synchrotron-light-and-middle-east

countries, the research identifies international best practices and strategies that Pakistan can adopt to enhance its science diplomacy efforts. The study concludes with recommendations for policymakers and stakeholders to foster a robust science diplomacy framework for Pakistan to build its image abroad and maximize socio-economic growth domestically.

Understanding Science Diplomacy

The conceptual evolution of science diplomacy can be traced to 17th-century scientific societies. These include the Royal Society of England, which was founded in 1660, and the Académie des Sciences of France, which was established in 1666. Both societies promoted the idea that science can be a neutral platform for dialogue, transcending political and cultural boundaries.[12] Moreover, the Cold War era (1947 to 1991) is considered one of the most important periods in science diplomacy. While competition between the US and USSR was intense in key areas such as space exploration and nuclear technologies, this rivalry also provided an opportunity for scientific cooperation. The launch of Sputnik satellites in 1957 by the USSR and the US moon landing in 1969 underscored how space exploration highlighted the strategic importance of science in projecting national power.[13]

During the same period, ideological divide among the two superpowers continued to exist, but they also began to realize that scientific collaboration could reduce tensions among them. In the 1960s, the US and USSR carried out scientific exchange programs in the health, environment, and space sectors.[14] The bilateral scientific exchange programs not only facilitated science but also sometimes served as a backchannel diplomacy during tense political periods.

In the post-Cold War era, the international community shifted its focus toward addressing global non-traditional challenges that required cooperation across national boundaries. International discourse on the peaceful uses of nuclear technology gained momentum through organizations such as the IAEA, as the global community gradually recognized the need for collective action on issues transcending national

[12]"History of the Royal Society." *The Royal Society*, https://royalsociety.org/about-us/who-we-are/history/

[13] Dinkel, Christopher. *Moon Rocks and Mediations: Cooperation and Competition in Space Race Diplomacy*. Master's thesis, Fort Hays State University, 2010, 166. https://doi.org/10.58809/UCZK1659 https://scholars.fhsu.edu/theses/166

[14] Dinkel, Christopher. "FHSU Scholars Repository." Fort Hays State University, 2010.

boundaries.[15] Owing to this momentum, various multilateral agreements were signed. On 12 June 1992, the UNFCCC was signed, placing environmental science at the heart of global governance.[16] Moreover, the Human Genome Project (1990-2003) illustrates how scientific collaboration emerged as a global priority in the post-Cold War period.[17] The project was a biological discovery led by an international group of researchers to study all of the DNA.

The term Science Diplomacy was first coined in 2003 by the then science and technology adviser to the US Secretary of the Department of State, Norman Neureiter. He defined science diplomacy as "[a]n intentional effort to engage with other countries where the relationship is not good otherwise."[18] In 2010, the American Association for the Advancement of Science (AAAS) organized the conference "New Frontiers of Science Diplomacy" in collaboration with the Royal Society and persuaded states to cooperate in the field of science diplomacy.[19] According to Director AAAS, Vaughan Turekian, "The use and application of science cooperation to help build bridges and enhance relationships between and amongst societies, with a particular interest in working in areas where there might not be other mechanisms for an engagement at an official level."[20] Nina Fedoroff, Science and Technology Adviser to the US Secretary of State from 2007-2010, stated that "Science diplomacy is the use of scientific collaborations among nations to address the common problems facing (twenty-first) century humanity and to build constructive international partnerships."[21] AAAS characterized science diplomacy into three categories:

Diplomacy for Science: This refers to diplomatic actions taken to facilitate international scientific collaboration by negotiating research and

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[15] Fischer, David. *International Atomic Energy Agency: The First Forty Years*. Vienna: International Atomic Energy Agency, 1997, 53–76, https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1032_web.pdf

[16] "What Is the United Nations Framework Convention on Climate Change?" *United Nations Climate Change*, 2022, https://unfccc.int/process-and-meetings/what-is-the-united-nations-framework-convention-on-climate-change

[17] Zhu, Tian, and Tito Carvalho. "The Human Genome Project (1990–2003)." *Embryo Project Encyclopedia*, Arizona State University, May 6, 2014, https://embryo.asu.edu/pages/human-genome-project-1990-2003

[18]Ruffini, Pierre. "Conceptualizing Science Diplomacy in the Practitioner-Driven Literature: A Critical Review," *Humanities and Social Sciences Communications* 7, no. 1 (2020): 1–9, https://doi.org/10.1057/s41599-020-00609-5

[19] Ruffini, Pierre. "Conceptualizing Science Diplomacy."

[20] "Science as a Tool for International Diplomacy." *Europa (CORDIS)*, https://cordis.europa.eu/article/id/30532-science-as-a-tool-for-international-diplomacy

[21] Ruffini, "Conceptualizing Science Diplomacy."

development agreements and exchange programs or enabling the establishment of international research infrastructures. European Organization for Nuclear Research, also known as CERN, is the best example of diplomacy for science.

Science for Diplomacy: It uses science to advance diplomatic objectives. The Antarctic Treaty System best defines science for diplomacy. It is an international agreement that governs research and conservation in Antarctica and exemplifies how science can be a catalyst for peaceful cooperation in a unique and challenging environment.[22]

Science in Diplomacy: It promotes the direct support of diplomatic processes through science by providing scientific advice and evidence to inform and support decision-making in foreign and security policies. The IPCC, which was established in 1988, brings together the world's leading climate scientists to assess the latest research on climate change. IPCC's reports provide policymakers with the scientific basis for international agreements such as the Paris Agreement and demonstrate the way science can inform and guide diplomacy on important global issues.[23]

Correlating Sustainable Development and Science Diplomacy

Sustainable development is a concept that integrates economic growth, environmental protection, and social equity to ensure the well-being of both current and future generations. The idea has evolved through numerous theoretical frameworks, each offering unique insights into how sustainable development can be achieved. The theory emphasizes a balanced approach regarding the relationship of the environment, economy, and society, and emphasizes long-term strategies. It provides the basis for global initiatives such as the UN 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs). The first definition that incorporated the concept of sustainable development was given in the "Brundtland Report," which was prepared by the Commission on Environment and Development (formally known as the Brundtland Commission) in 1987. The then-chair of the commission, Dr. Gro Harlem Brundtland, defined sustainable development as "development that meets

[22] "The Antarctic Treaty Explained", British Antarctic Survey," 2015, https://www.bas.ac.uk/about/antarctica/the-antarctic-treaty/the-antarctic-treaty-explained/.
[23] Intergovernmental Panel on Climate Change, "History", IPCC, 2019, https://www.ipcc.ch/about/history/.

the needs of the present without compromising the ability of future generations to meet their own needs."[24]

Sustainable development theory offers perspectives on how science diplomacy can pave the way for cooperation among nations. By aligning its diplomatic initiatives with the principles of sustainability, Pakistan can position itself as a proactive contributor to addressing transnational challenges such as climate change, renewable energy transitions, water security, and food sustainability. Pakistan can advance sustainable development practices within the science diplomacy framework, unlocking its potential to become a leading regional and global player in utilizing scientific innovation.

State of Science Diplomacy in Pakistan

Pakistan has also taken several initiatives to promote science diplomacy because of its significance. In 2022, Pakistan launched its National Science, Technology, and Innovation Policy to provide guidelines for the country's science diplomacy. It acknowledges science as an important enabler of socio-economic development and calls for intensified international cooperation in scientific research and innovation.[25] The policy provides clear objectives aimed at expanding the scientific and technological output of Pakistan while promoting cooperation with multilateral organizations in various scientific areas, including biotechnology, renewable energy, health security, and science diplomacy.[26]

Pakistan has pursued science diplomacy through both bilateral and multilateral channels. It has entered into cooperation agreements with technologically advanced countries and undertaken several notable bilateral initiatives aimed at strengthening scientific collaboration. In 2005, the United States Agency for International Development (USAID), in collaboration with Pakistan's Ministry of Science and Technology (MOST) and the Higher Education Commission (HEC), launched the Pakistan-US Science and Technology Cooperation Program. The objectives of this

[24] "1987: Brundtland Report," United Nations, March 20, 1987, https://www.are.admin.ch/are/en/home/media/publications/sustainable-development/brundtland-report.html

[25] Government of Pakistan, Ministry of Science and Technology, *"National Science, Technology and Innovation Policy",* (Islamabad, Pakistan Council for Science and Technology, January 2022), https://most.comsatshosting.com/Policies/NSTPolicy2022.pdf

[26] Government of Pakistan, *"National Science, Technology and Innovation Policy."*

program are: (i) to strengthen the community of science and technology in Pakistan for improving economic development; (ii) to raise the standard, applicability and capability of science and technology-related higher education and research at Pakistani institutions of higher learning; and (iii) to enhance the capability of Pakistan's research institutes to support competitiveness in the industry.[27]

Another initiative is the US-Pakistan Centers for Advanced Studies (USPCAS), which was established in partnership with Pakistani universities, focusing on energy, water, and agriculture to address Pakistan's specific developmental needs. The US Government, through USAID, and the Government of Pakistan through the HEC, partnered together to create state-of-the-art centers for advanced studies.[28] The five-year program, which spanned from 2014 to 2019, successfully established centers that remain operational to this date.[29] The USPCAS established: (i) Two Centers for Advance Studies in Energy at the National University of Science and Technology (NUST) Islamabad and the University of Engineering and Technology (UET) Peshawar, which focuses on clean energy technologies; (ii) Center for Advance Studies in agriculture at University of Agriculture Faisalabad, which focuses on crop improvement and biotechnology, water management and irrigation and agricultural economies and policy; and (iii) Center for Advance Studies in Water at Mehran University of Engineering and Technology, Jamshoro, which focuses on water resource management, sustainable water use and improved water quality.[30]

Pakistan and China are also engaged in science diplomacy. Beijing and Islamabad enjoy a long history of cooperation in joint space projects that date back to the 1970s. The first satellite indigenously made in Pakistan, Badar-1, was launched in 1992 from China.[31] The China-Pakistan Economic Corridor (CPEC) is the flagship project of the Belt and Road Initiative (BRI). To support CPEC, the China-Pakistan Joint Research Centre (CPJRC) was established to focus on scientific problems in earth

[27] U.S. Agency for International Development. "U.S.–Pakistan Science & Technology Cooperative Program: Archive," https://2012-2017.usaid.gov/news-information/fact-sheets/us-pakistan-science-technology-cooperative-program

[28] "About U.S.–Pakistan Center for Advanced Studies in Water." *USPCAS-W*, April 16, 2019, https://water.muet.edu.pk/about-us

[29] US–Pakistan Centers for Advanced Studies in Energy." *USPCAS-E*, https://uspcase.asu.edu/

[30] "About U.S.-Pakistan Center for Advanced Studies in Water," USPCAS-W, April 16, 2019, https://water.muet.edu.pk/about-us/.

[31] SVI Administrator, "Pakistan-China Space Cooperation" *Strategic Vision Institute*, February 28, 2021, https://thesvi.org/pakistan-china-space-cooperation/.

sciences.[32] It will become an international platform for the China-Pakistan scientific and technological cooperation with prominent experts from both countries. On November 28, 2022, the China-Pakistan Science and Technology Cooperation Centre was established in Beijing to boost science and technology collaboration. The center focuses on cooperation in the fields of AI, Internet of Things (IoT), big data, cloud computing, robotics, fintech, biotechnology, and blockchain.[33]

China and Pakistan have signed an agreement to facilitate the transfer of civil nuclear technology to Pakistan, including nuclear power reactors.[34] China is the only country cooperating with Pakistan in the nuclear energy sector.[35] The Karachi Nuclear Power Plant (K2) and K3, and the four nuclear power plants located at Chashma, reflect strong bilateral ties and technological exchanges between the two countries. Pakistan Atomic Energy Commission (PAEC) is responsible for the development and management of the civilian use of nuclear technology in Pakistan. The four Chashma nuclear power plants collectively generate 1,335 MWe. An agreement for Chashma 5 (C5) with 1,200 MWe capacity has been concluded with China. The addition of K2 and K3 with a capacity of 1100 MWe each, further proves Pakistan's continued progress in this field. These plants are cost-effective and are making nuclear energy one of the most affordable options compared to other energy sources. Under its Nuclear Energy Vision 2050, Pakistan plans to produce 42,000 MWe, which would account for one-fourth of the country's energy needs. In 2023-2024, nuclear energy contributed about 18 percent to Pakistan's energy mix.[36] The growth in the production of nuclear power will not only meet Pakistan's increasing energy demand but also help to mitigate the effects of climate change and facilitate socio-economic development.

Pakistan has also established university-based international projects, including the International Center for Chemical and Biological Sciences (ICCBS) located at the University of Karachi. The initial impetus came

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[32] "Introduction: CPEC Data Sharing Platform for Resources, Environment, Ecology and Disaster," Cpjrc.net, http://www.cpjrc.net/page/introduction.
[33] Sana Jamal, "Pakistan, China Launch New Centre to Boost Tech Cooperation," *Gulf News,* 2 December 2022, https://gulfnews.com/world/asia/pakistan/pakistan-china-launch-new-centre-to-boost-tech-cooperation-1.92443426.
[34] Sher Ali Kakar, "Pak-China Nuclear Energy Cooperation," *The Nation,* January 11, 2025, https://www.nation.com.pk/11-Jan-2025/pak-china-nuclear-energy-cooperation.
[35] World Nuclear Association, "Nuclear Power in Pakistan," updated November 17, 2025, https://world-nuclear.org/Information-Library/Country-Profiles/Countries-O-S/Pakistan
[36] Government of Pakistan, Finance Division, *Energy,* Islamabad: Finance Division, 2024, https://www.finance.gov.pk/survey/chapter_24/14_energy.pdf

from academicians, but the initiative is supported and funded by the government of Pakistan. ICCBS is internationally recognized as a Center of Excellence by UNESCO, the Organization of Islamic Cooperation (OIC), and the World Academy of Sciences (TWAS). The ICCBS has developed extensive partnerships with institutions in more than 80 countries worldwide. These collaborations involve training young researchers at the graduate and postgraduate levels, establishing centres of excellence in multiple disciplines, jointly organizing capacity-building programs, and undertaking collaborative research projects.[37]

Another major initiative by Pakistan is the establishment of the National Aerospace Science and Technology Park (NASTP) in 2019.[38] It is located in Karachi and Islamabad. NASTP has emerged as a key hub for advancing national and international science and technology projects, playing an important role in growing innovation and collaboration in the aerospace and high-tech sectors. It is currently home to more than 60 companies ranging from entrepreneurial start-ups to multinational companies from Türkiye, China, the US, UAE, New Zealand and Switzerland working across eight distinct themes of the park that include: AgriTech, AutoTech, EduTech, EnergyTech, FinTech, HealthTech, SmartTech and DefTech.[39]

In 2018, the Foreign Ministry of Pakistan launched its Science Diplomacy Initiative (SDI) under the Science Diplomacy Division, which was established in 2016 to promote scientific cooperation between Pakistan and international stakeholders such as research institutes, international organizations, multi-national companies, and universities. SDI focuses on strengthening collaboration in targeted fields, including research and development, renewable energy, agriculture, health, and climate change, all of which align with the UN-led SDGs.[40] SDI has also built partnerships with international science and technology institutions and research organizations across multiple countries. Through joint research activities, workshops, and

[37] Chaudhary, Muhammad Iqbal, and Hina Siddiqui. "Science Diplomacy: Role of International Center for Chemical and Biological Sciences, University of Karachi, Pakistan—An Example of Sustainable Cooperation Across the Globe." *Science Diplomacy Perspectives* 1, no. 1 (2022): 101.
[38] National Aerospace Science & Technology Park. "National Aerospace Science & Technology Park (NASTP)," https://nastp.gov.pk/
[39] "IASP Global Directory of Science & Technology Park & Innovation District." *International Association of Science Parks and Areas of Innovation (IASP)*, https://www.iasp.ws/our-members/directory/@6166/national-science-and-technology-park--nstp-
[40] Ahmed, Monir Uddin, et al. "An Overview of Science Diplomacy in South Asia." *Science & Diplomacy*, February 17, 2021, https://www.sciencediplomacy.org/article/2021/overview-science-diplomacy-in-south-asia.

seminars, it promotes the exchange of scientific knowledge and technical expertise.

In the academic domain, the Ministry of Foreign Affairs, in collaboration with the OIC Standing Committee on Scientific and Technological Collaboration (COMSTECH), launched the first issue of its science diplomacy Journal titled *Science Diplomacy Perspectives* in March 2022.[41] The journal comprises in-depth scholarly contributions from career diplomats, subject-matter experts, and academics, encompassing a wide array of issues pertaining to science and technology.

At the international level, Pakistan has been engaged with international centers for scientific research. In 2014, Pakistan was the first Asian country that become an associate member of the CERN,[42] highlighting Pakistan's involvement in cutting-edge scientific research. Scientists from Pakistan participate in high-energy physics research and collaborate with leading scientists around the world. Pakistan has been a key partner of the International Centre for Theoretical Physics (ICTP). Various physicists, mathematicians, and computer scientists from Pakistan engage in ICTP programs, contributing to research in the fields of quantum mechanics, climate modeling, and computational science.[43]

Pakistan, being a founding member of the IAEA, supports peaceful nuclear research and development, with a focus on improving health, agriculture, and environmental sustainability. Pakistan has collaborated with the IAEA on cancer research and treatment, resulting in the development of nuclear medicine facilities that provide early diagnosis and treatment of cancer. Through IAEA's assistance, Pakistan has made significant advancements in crop improvement, pest control, and food preservation, using nuclear techniques to enhance food security.[44]

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[41] "Launch of the First Issue of 'Science Diplomacy Perspectives.'" *Ministry of Foreign Affairs, Pakistan*, March 15, 2022, https://mofa.gov.pk/press-releases/launch-of-the-first-issue-of-science-diplomacy-perspectives

[42] "Pakistan Becomes the First Associate CERN Member from Asia." *Ministry of Foreign Affairs, Pakistan*, 2014, https://mofa.gov.pk/pakistan-becomes-the-first-associate-cern-member-from-asia

[43] "Pakistan: ICTP." *International Centre for Theoretical Physics (ICTP)*, 2024, https://www.ictp.it/taxonomy/term/106

[44] Aftab, Ambassador, and Ahmad Khokher. "Pakistan and the IAEA: A Mutually Beneficial Partnership." *Special Guest Articles*, 2023, https://issi.org.pk/wp-content/uploads/2023/11/Article-Pakistan-and-the-IAEA-A-Mutually-Beneficial-Partnership-by-Ambassador-Aftab-Ahmad-Khokher.pdf

Science Diplomacy

Pakistan is committed to cooperating in space exploration with other nations. In 2022, the third international conference on space was held by the Space and Upper Atmosphere Research Commission (SUPARCO), Pakistan's space agency, and is an example of Pakistan's commitment to enhancing its space capabilities. Participants from South Korea, Australia, China, Türkiye, Azerbaijan, the UAE, Italy, Canada, and many others attended the conference.[45]

Pakistan is also leveraging science diplomacy at the regional level to address common challenges with neighboring countries. As a member of ECO, Pakistan has contributed to the establishment of the ECO Science Foundation, which promotes scientific collaboration among member states. The foundation focuses on capacity building in science and technology through cooperative research and knowledge-sharing. [46]

Although the SCO does not have a dedicated body exclusively for scientific and technological collaboration, it has launched several initiatives to foster cooperation in these fields, which include: (i) regular Meetings of Heads of Ministers and the Department of Science and Technology of the SCO Member States.[47] Pakistan actively participates in this regular meeting to seek collaboration in IT, biotechnology, energy, and health sciences; and (ii) the SCO University Network established in 2008 allows student exchange programs, joint degrees, and research collaboration in engineering, IT, and environmental sciences. In July 2025, the National University of Sciences and Technology (NUST) joined the SCO University Network for Digital Economy Education, partnering with leading regional universities to promote collaboration in AI, big data, and cross-border e-commerce.[48]

During the COVID-19 Pandemic, Pakistan's science diplomacy was evident in its efforts to secure vaccines and engage in international partnerships for health security. Pakistan's collaboration with China on

[45] Mumtaz, Muhammad. "International Conference on Space 2022." *COMSTECH*, December 31, 2021, https://comstech.org/international-conference-on-space-2022/
[46] "ECO Science Foundation Established." *Dawn*, December 21, 2011, https://www.dawn.com/news/682182/eco-science-foundation-established
[47] "Meeting of Heads of Ministries and Departments of Science and Technology of the SCO Member States." *Shanghai Cooperation Organisation*, June 21, 2024, https://eng.sectsco.org/20240621/1400265.html
[48] "Rector NUST at the Signing of the SCO University Alliance for Digital Economy Education." *National University of Sciences and Technology (NUST)*, 2017. Accessed September 2, 2025, https://nust.edu.pk/news/rector-nust-at-the-signing-of-the-sco-university-alliance-for-digital-economy-education/

vaccine development, including the co-production of the Sinopharm and Sinovac vaccines, demonstrated the country's ability to leverage diplomatic ties for critical scientific and health needs.[49] In 2021, Pakistan's Ministry of Foreign Affairs, through the SDI, hosted a coordination meeting to discuss international collaboration and partnerships in vaccine production. On the occasion, the then Foreign Secretary, Ambassador Sohail Mehmood, emphasized the importance of achieving self-reliance in vaccine production and strengthening national health security efforts through international partnerships and collaboration.[50] Pakistan has also joined global initiatives such as the Coalition for Epidemic Preparedness Innovations (CEPI) and participated in the COVAX facility, which seeks equitable vaccine access for all countries. This collaboration is an important aspect of Pakistan's science diplomacy aimed at enhancing global health security.

Pakistan's Potential as a Hub for Regional Cooperation in Science and Technology

Pakistan holds significant potential to serve as a hub for regional cooperation in science and technology, given its strategic geographic location bridging South Asia, Central Asia, and the Middle East. With a large pool of skilled scientists, expanding research institutions, and its role in multilateral forums, Pakistan can facilitate collaborative research, technology transfer, and innovation partnerships. Strengthening this role could not only advance national and regional development but also enhance Pakistan's position in global science diplomacy. The paper has identified five potential areas of cooperation, which are as follows:

Science Diplomacy in the Extraction of Mineral Resources

Pakistan is a resource-rich country. Mineral resources play a pivotal role in Pakistan's economic development, and through science diplomacy, Pakistan can capitalize on them for regional cooperation. The country possesses the world's second-largest salt mines, fifth-largest copper and gold reserves, and the second-largest coal deposits. Despite this vast potential, the mineral sector contributes only about 3 percent to Pakistan's GDP, and its exports

[49] Siddiqui, Adeel, et al. "An Overview of Procurement, Pricing, and Uptake of COVID-19 Vaccines in Pakistan." *Vaccine*, July 2021, https://doi.org/10.1016/j.vaccine.2021.07.072

[50] "Coordination Meeting on International Cooperation and Partnerships in Vaccine Production." *Ministry of Foreign Affairs, Pakistan*, 2021, https://mofa.gov.pk/coordination-meeting-on-international-cooperation-and-partnerships-in-vaccine-production

account for merely 0.1 percent of the global total.[51] Pakistan could partner with technologically advanced countries to conduct research in sustainable extraction of natural resources, environmental conservation, and mineral processing. Collaboration with countries like China, the US, Canada, Japan, and the EU could lead to technology transfer, enabling Pakistan to adopt greener mining practices.[52] On 30 July 2025, the US and Pakistan signed a trade deal that expands cooperation in energy, rare earth minerals, hydrocarbons, digital infrastructure, and joint exploration of Pakistan's oil reserves.[53] On 7 September 2025, Pakistan signed a Memorandum of Understanding (MoU) for the investment of $500 million with the US Strategic Metals (USSM) to explore critical mineral resources, including copper, gold, and rare earth minerals.[54] The deal will boost Pakistan's economic growth, attract advanced US technology and investment, improve foreign exchange earnings, strengthen industrial capacity, and elevate Pakistan's role in regional and global trade networks.

Exploring Untapped Blue Economy

The blue economy is another area of regional cooperation through science diplomacy. As a country with an extensive coastline, Pakistan holds significant potential to leverage its strategic geographic position for seaborne trade. Given the growing demand for sustainable development and effective resource management, Pakistan should transition toward a blue economy. The major sectors in Pakistan's blue economy are ports and infrastructure, fisheries, renewable energy production, shipping, and maritime tourism.[55] With around 1,049 km of coastline and ports, including Karachi Port Trust, Port Muhammad Bin Qasim, and Gwadar Port

[51] Akhtar, Syed, and Hussain Shah. *Strategy for Mineral Sector Development in Pakistan*. Islamabad: Planning Commission of Pakistan, Ministry of Planning, Development & Reform, Government of Pakistan, 2018, https://www.pc.gov.pk/uploads/pub/FIRST_05_PAGES_STRATEGY_FOR_MINERAL_SECTOR_DEVELOPMENT_IN_PAKISTAN.pdf

[52] Mehmood, Saima, et al. "The Role of Green Industrial Transformation in Mitigating Carbon Emissions: Exploring the Channels of Technological Innovation and Environmental Regulation." *Energy and Built Environment* 5, no. 3 (2024): 464–479, https://doi.org/10.1016/j.enbenv.2023.03.001

[53] Shahid, Ariba, et al. "Pakistan Says It Wins US Tariff Deal; Trump Cites Oil Reserves Pact." *Reuters*, July 31, 2025. https://www.reuters.com/world/asia-pacific/pakistan-says-it-wins-us-tariff-deal-trump-cites-oil-reserves-pact-2025-07-30/

[54] Momand, Abdullah, and Sanaullah Khan. "US Metals Company Signs $500m MoU with Pakistan on Critical Minerals." *Dawn*, September 8, 2025, https://www.dawn.com/news/1940515

[55] Wenhai, Lu, et al. "Successful Blue Economy Examples with an Emphasis on International Perspectives." *Frontiers in Marine Science*, vol. 6, 7 June 2019, www.frontiersin.org/articles/10.3389/fmars.2019.00261/full, https://doi.org/10.3389/fmars.2019.00261.

Authority, Pakistan is now strategically positioned to enhance its access to international trade and energy supply routes. With an Exclusive Economic Zone (EEZ) covering approximately 240,000 square km, along with an additional 50,000 square km of continental shelf, the country's maritime territory holds vast, largely unexplored deep-sea resources. Pakistan's blue economy currently contributes approximately USD 1 billion, or around 0.4 percent of the national GDP.[56] According to Pakistan's Ministry of Maritime Affairs, the blue economy's estimated potential exceeds USD 100 billion, underscoring substantial untapped opportunities for economic growth and development through the sustainable utilization of oceanic resources.[57]

Partnering with maritime technologically advanced countries, such as Norway, Japan, and Australia, Pakistan can develop expertise in marine sciences, including sustainable fisheries, marine biotechnology, and environmental monitoring. Science diplomacy can help Pakistan access international expertise in aquaculture, diversifying its fishing economy and contributing to food security. Countries like China and Thailand, which have expertise in aquaculture, could help promote sustainable practices and increase Pakistan's aquaculture scope. [58]

There are various international models available for cooperation in the blue economy that emphasize technology sharing to protect and develop ocean resources. The EU's Blue Growth Strategy promotes sustainable marine industries through research partnerships,[59] UNESCO's Ocean Decade unites countries to address pollution and marine biodiversity. Australia's Indo-Pacific Oceans Initiative (IPOI) strengthens regional maritime governance, and the US National Oceanic and Atmospheric Administration (NOAA) global partnerships on ocean science support capacity building worldwide. Additionally, Norway's High-Level Panel advocates sustainable ocean use through policy-driven collaboration, and the Indian Ocean Rim Association (IORA) fosters cooperative marine projects across

[56] Lu, Wenhai, et al. "Successful Blue Economy Examples with an Emphasis on International Perspectives." *Frontiers in Marine Science* 6 (June 7, 2019), https://doi.org/10.3389/fmars.2019.00261

[57] Dr Samar Iqbal Babr and Muhammad Danish Masood, "Pakistan's Quest for Sustainable Maritime Development", *Strategic Thought* 6 (1):125-38, http://111.68.99.125/st/site/article/view/121.

[58] Giri, Shiba S. "Sustainable Aquaculture Practices in South Asia: A Comparative Analysis of Feed Formulation and Utilization." *Animal Frontiers* 14, no. 4 (2024): 6–16, https://doi.org/10.1093/af/vfae020

[59] "Sustainable Blue Economy." *European Commission – Oceans and Fisheries*, https://oceans-and-fisheries.ec.europa.eu/ocean/blue-economy/sustainable-blue-economy_en

the region. For Pakistan, joining similar initiatives could enhance its blue economy by expanding research capabilities, improving resource management, and accessing advanced marine technology.

Science Diplomacy for Mitigating Climate Change

Pakistan's vulnerability to climate change necessitates proactive diplomatic engagement with global partners in climate resilience initiatives. Through international collaboration, Pakistan can strengthen the research capabilities in glaciology, hydrology, and agriculture areas that are vital for an agrarian economy highly exposed to climate variability.[60] Science diplomacy provides opportunities to foster partnerships with agricultural research organizations to develop climate-resilient crops and sustainable farming practices. At the same time, collaboration with countries experienced in disaster response and climate adaptation, such as Japan and China, can help Pakistan improve early warning systems, flood control mechanisms, and urban planning, thereby enhancing resilience against increasingly frequent climate-induced disasters.[61] Beyond agriculture and disaster preparedness, Pakistan can leverage science diplomacy to build partnerships in renewable energy, water management, and digital climate solutions.

Pakistan has been actively participating in the UNFCCC**,** IPCC, and UNEP, which allows Pakistan to advocate for climate justice, technology transfer, and capacity-building support. Joint research projects with advanced countries and regional organizations in green technologies, glacier monitoring, and climate-smart agriculture, along with bilateral and multilateral science agreements,[62] will provide Pakistan access to funding, expertise, and clean technologies. By promoting academic exchange, data-sharing, and participation in global climate innovation hubs, Pakistan can further strengthen evidence-based policymaking, enhance national adaptive capacity, and position itself as a constructive contributor to global climate action.

[60] Mehwish, Sabeen Azam, Akhlaque Hussain Larik, Zuberia Sadiq, Sadaf Jan Siddiqui, and Umaima Iqbal. "Pakistan's Approach to Climate Change Diplomacy: An Analysis of SDG 13." *Dialogue Social Science Review (DSSR)* 3, no. 4 (2025): 91–109, https://thedssr.com/index.php/2/article/view/458

[61] Mehwish, Azam, Hussain Larik, Sadiq, Siddiqui, and Iqbal. 2025. "Pakistan's Approach to Climate Change Diplomacy: An Analysis of SDG13."

[62] "Pakistan's Approach to Climate Change Diplomacy: An Analysis of SDG13."

Training and Capacity Building Workshops in the Peaceful Uses of Nuclear Energy

Pakistan is providing technical assistance in the peaceful utilization of nuclear technology to other countries. Pakistan's Center of Excellence and Nuclear Security (PCENS) aims to provide training in collaboration with the IAEA on nuclear security, intelligence, technical training, and counter-intelligence to security forces.[63] In March 2016, PCENS hosted the annual meeting of the Nuclear Security Support Center (NSSC) network. This marked the first occasion on which the IAEA convened an NSSC meeting outside its Vienna Headquarters, with 50 participants representing 33 countries in attendance.

Science Diplomacy for Vaccine Development

Just like any developing state, Pakistan faces challenges like infectious diseases, malnutrition, and non-communicable diseases. Science diplomacy can facilitate international collaboration on vaccine development, disease surveillance, and pandemic preparedness. For Pakistan, establishing its vaccine Development complex is not just a matter of health security but a strategic imperative to ensure timely access to life-saving vaccines.

Pakistan can develop its vaccine by collaborating with China, Brazil, Cuba, and Vietnam, which are producing and supplying the vaccine to other countries. China, one of the leading manufacturers of vaccines, has collaborated with Pakistan during the COVID-19 pandemic, providing vaccines and expertise. China can offer technology transfer, training, and investment in local vaccine manufacturing facilities. In July 2021, Cuba offered to establish a vaccine production center in Pakistan to cater to both domestic needs and potential export. The proposal was put forward by the Cuban Ambassador, Zener Javier Caro Gonzalez, during his meeting with Pakistan's Federal Minister for Science and Technology.[64]

Pakistan can engage with the Vaccine Manufacturers Network (DCVMN), which plays a key role in strengthening both the technical and operational capacities of vaccine producers. Similarly, Brazil signed an MoU with Gavi, the Vaccine Alliance, to collaborate on vaccine production,

[63] Rahat Iqbal, "Enabling Environment for Peaceful Uses of Nuclear Energy in Pakistan" *Stratheia,* July 11,2023, https://stratheia.com/enabling-environment-for-peaceful-uses-of-nuclear-energy-in-pakistan/.
[64] Muhammad Ishtiaq, "Cuba Offers to Establish Vaccine Production Center in Pakistan," *Arab News*, July 14, 2021, https://www.arabnews.pk/node/1893896/spa/aggregate.

innovation, and global access. The same MoU can be signed between Pakistan and Gavi.

In Basic manufacturing, Pakistan's National Institute of Health (NIH) can play an important role in building the vaccine development complex in Pakistan. By investing in local research, strengthening manufacturing capacity, and engaging in science diplomacy, Pakistan can reduce its dependence on external sources and be better prepared to face future diseases and pandemics. This approach will also position the country as a key player, contributing to regional and international efforts to ensure equitable access to vaccines and improved public health outcomes.

Recommendations

Science diplomacy is a vital area for Pakistan to focus on. Pakistan needs to increase funding for scientific research to stimulate innovation and enhance its scientific capabilities. Regional funding bodies, similar to the EU's flagship Horizon program, can be established to promote joint research on regional challenges.[65]

More so, regional collaboration can be enhanced by deepening ties with neighboring countries as well as Central Asian states. This approach may include joint research initiatives, technology transfer, and knowledge exchange programs to harness shared resources and expertise for the benefit of mutual growth and development.

In order to close the communication gap between scientists, decision-makers, and the general public, science communication training programs can be initiated.

Pakistan should focus on harnessing scientific expertise to address national and regional challenges, such as climate change, public health crises, and food security, through diplomatic channels. For this, ensuring simple and quick visa access for scientists in the region by allowing them to travel to attend conferences or collaborate on projects is needed.

There is a need to appoint experienced professionals as "tech diplomats" to act as intermediaries between scientific communities, governments, and international stakeholders. These tech diplomats should have a deep

[65] Monir Uddin Ahmed, et.al, "An Overview of Science Diplomacy in South Asia," *Science & Diplomacy*, February 17, 2021, https://www.sciencediplomacy.org/article/2021/overview-science-diplomacy-in-south-asia.

understanding of both foreign policy and science and technology to effectively facilitate collaboration, negotiate agreements, and advance science and technology diplomacy globally. The Netherlands pioneered this approach in May 2017 by appointing its first tech diplomat to Silicon Valley, California, a move that proved highly successful. Since then, numerous countries around the world have followed suit by appointing their own tech diplomats.

In light of the COVID-19 experience and global vaccine nationalism, Pakistan has an opportunity to take a leading role in vaccine development partnerships as part of regional health security initiatives. Establishing a self-sustaining vaccine development hub, backed by science diplomacy, would enable Pakistan to lessen its reliance on external suppliers for critical health resources while strengthening health resilience across the region.

On 30 July 2025, Pakistan approved the National Artificial Intelligence (AI) Policy 2025, which aims to establish a robust governance structure through the creation of an AI Council, the publication of a regulatory framework, and the introduction of AI Innovation and Venture Funds. It also aims to train one million AI professionals by 2030.[66] By aligning its standards with international best practices and fostering institutional partnerships, Pakistan can proactively engage with leading nations in AI, such as the US, China, and the European Union, to secure technical expertise, attract foreign investment, and participate in global forums.

According to the Global Electricity Review 2025 report, Pakistan imported a remarkable 17 GW of solar panels in 2024, placing the country among the world's top solar markets.[67] To accelerate Pakistan's solar transition, the government should leverage strategic partnerships with China and the EU, which are leaders in solar technology, to promote technology transfer, joint research and development, and capacity-building programs.

Conclusion

Pakistan has made notable advancements in science diplomacy through various initiatives at both bilateral and multilateral levels, but substantial untapped potential exists to further leverage this approach for the country's

[66] Sohail Rao, Pakistan's National AI Policy in 2025, A Comparative Appraisal, Advantages, Risks, Execution, Pathways and Regional Benchmarks, *Innovapath: The Premium Journal Discovery and Innovation,* Vol 1, no 7 (2025), 1-12, https://doi.org/10.63501/2p23r912

[67] "Pakistan, Saudi Arabia Became World's Largest Markets for New Solar Installations in 2024 — Report." *Arab News*, Arabnews, April 14, 2025, www.arabnews.com/node/2596952/pakistan

socio-economic development. With a focus on strategic sectors such as the blue economy, food security, climate change, peaceful uses of nuclear technology, and the extraction of mineral resources, Pakistan has an opportunity to strengthen its science diplomacy efforts. By building and deepening collaborative partnerships in these areas, the country can not only achieve sustainable growth but also enhance its role as a responsible global actor committed to tackling pressing challenges.

To fully capitalize on the opportunities offered by science diplomacy, Pakistan can prioritize investments in human capital, cultivate a culture of innovation, and strengthen its institutional frameworks for international cooperation. This will require focused efforts to enhance research capabilities, improve education and training programs, and create an enabling environment that fosters scientific exchange and collaboration. Strengthening the country's scientific infrastructure and ensuring the effective retention of skilled professionals will be essential to creating a competitive and robust scientific community that can contribute to both national and global development. It will contribute not only to the country's socioeconomic development but also to the broader scientific and technological progress necessary to address shared global challenges. With determined effort and strategic planning, Pakistan has the potential to harness the full potential of science diplomacy, positioning itself as a key player in the pursuit of sustainable development, peace, and global cooperation.