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Iranian Science Diplomacy: Management Systems, Strategic Policies, and Sino-Iranian Collaboration

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Abstract

This study analyzes Iran's science diplomacy amidst intricate geopolitical dynamics, focusing on its institutional mechanisms, strategic priorities, and collaborative potentials. Iran's unique governance model—characterized by multi-sectoral coordination under government leadership—has bolstered advancements in energy, defense, and agriculture, laying a foundation for its science diplomacy. Strategically, Iran adopts a diversified approach, fostering regional and global partnerships to enhance technological synergies in energy, information technology, and biotechnology, particularly with Russia, China, and India. However, challenges such as international sanctions, regional instability, and domestic R&D limitations impede progress. Notably, Sino-Iranian collaboration, rooted in historical ties and the Belt and Road Initiative, has expanded from traditional sectors (e.g., agriculture) to cutting-edge fields like AI and renewable energy. While complementarity and dynamic growth characterize this partnership, obstacles remain, including geopolitical tensions, technical standard disparities, and cultural barriers. This research underscores Iran's resilience in leveraging science diplomacy to navigate global challenges and highlights the transformative potential of Sino-Iranian cooperation in advancing regional innovation ecosystems. Findings offer theoretical insights and practical guidance for deepening bilateral ties, enhancing global technological influence, and promoting sustainable development in the Middle East and beyond.

Keywords: Iran, Science diplomacy, China - Iran science diplomacy

1.Introduction

In an era defined by globalization and rapid technological advancements, science diplomacy has emerged as a pivotal instrument for nations seeking to enhance competitiveness and project soft power. As a cornerstone of international relations, it bridges scientific collaboration with geopolitical strategy, enabling states to address global challenges while advancing national interests. Iran, a nation with profound geopolitical significance, abundant natural resources, and a rich cultural heritage, occupies a unique position in this landscape. Its pursuit of science diplomacy is shaped by a confluence of factors: its role as a pivotal Middle Eastern actor, its complex relationship with Western powers, and its ambition to carve out a niche in the global technology ecosystem. This study interrogates the efficacy of Iran's science diplomacy through a dual lens—analyzing its institutional frameworks and strategic partnerships—while spotlighting the implications for Sino-Iranian collaboration.

Recent shifts in the geopolitical landscape and technological paradigms have compelled Iran to recalibrate its science diplomacy strategy. The enduring nuclear imbroglio, characterized by protracted tensions with Western nations, has imposed dual constraints and incentives. On one hand, punitive sanctions have stymied access to cutting-edge technologies and multinational R&D networks. On the other, they have catalyzed indigenous innovation and strategic alliances with non-Western partners. These dynamics raise contentious questions: Can Iran leverage its scientific prowess to circumvent geopolitical isolation? To what extent do partnerships with countries like China and Russia mitigate the impacts of sanctions? Such debates underscore the need for nuanced analysis of Iran's evolving approach to science diplomacy.

Against this backdrop, Sino-Iranian collaboration under the Belt and Road Initiative (BRI) presents both opportunities and challenges. While infrastructure and energy projects have flourished, deeper technological synergies in areas like AI, biotechnology, and renewable energy remain nascent. Critics highlight asymmetries in technical standards, divergent regulatory frameworks, and lingering geopolitical risks. Yet proponents argue that shared interests in regional stability and economic diversification could drive unprecedented cooperation. This study adopts a mixed-methods approach, integrating qualitative policy analysis with quantitative assessments of bilateral R&D investments, to elucidate pathways for enhancing Sino-Iranian scientific partnerships. By unpacking these complexities, the research aims to furnish actionable insights for policymakers and scholars invested in fostering resilient global innovation networks.

2.The Science and Technology Management System of Iran

2.1. Management System

Iran's science and technology management system exhibits a "government-led, multi-sector coordinated, and academia-supported" composite structure. At the strategic level, the Presidential Office coordinates resource allocation across 14 ministries (including Defense, Education, and Industry) through the Highest Scientific Committee, adopting a "triple-helix" decision-making model: the Supreme Leader's Office exercises final authority via the "Expert Commission" to approve national science and technology development plans;[1] the Ministry of Science, Research, and Technology (MSRT) acts as the core executive body, overseeing project approvals, resource distribution, and innovation ecosystem cultivation (e.g., fostering 2,900 knowledge-intensive enterprises post-2010 Knowledge Company Support Law); and universities/research institutes form an innovation matrix. Prestigious institutions like Tehran University (ranking 17th globally in publications) excel in engineering (H-index 182) and nanomaterials (ESI top 1%),[2] while the Atomic Energy Organization operates three national laboratories for nuclear R&D. Despite sanctions, Iran maintained a 44% government science budget share in 2017 (with 28% allocated to basic research),[3] channeling

72% of competitive research funds to five leading universities through performance-based evaluations. This system drove a 420% decade-long growth in materials science publications.[4] Yet challenges persist: R&D intensity languishes at 0.92% (2016), international co-authorship remains low (21%), and high-tech equipment localization hovers below 40% due to import restrictions. Recent breakthroughs include indigenous satellite launches and joint ventures like the EU-funded Clean Energy Research Center, yet systemic bottlenecks underscore the uphill climb toward a knowledge-driven economy.

2.2. Operational Mechanism

Iran's science and technology (S&T) R&D framework exhibits a diversified operational mechanism, integrating government funding, private-sector participation, and international collaboration.

The government acts as a strategic guide through funding mechanisms like the National Science Foundation, which finances critical research in alignment with national priorities. Strategic sectors such as energy, defense, and agriculture receive targeted investments. For example, in the energy sector, state-funded projects focus on advancing petroleum exploration technologies, natural gas extraction innovations, and renewable energy development. These initiatives aim to enhance Iran's technological self-reliance and global competitiveness in energy markets.

The private sector is emerging as a key driver in applied technology R&D. As Iran's economy evolves, businesses increasingly collaborate with universities and research institutes to commercialize innovations. A notable example is the partnership between Iranian automotive manufacturers and research entities to co-develop advanced vehicle production technologies. Such collaborations enable institutions to provide cutting-edge solutions—such as energy-efficient engines or smart manufacturing systems—while enterprises apply these technologies to improve product performance and market value, thereby bridging the gap between academic research and industrial application.

Internationally, Iran actively participates in global R&D networks. Collaborative projects span climate change studies, medical research, and agri-tech innovation, with Iranian scientists contributing expertise while absorbing advanced methodologies. These partnerships not only facilitate knowledge exchange and technology transfer but also elevate Iran's visibility in global scientific discourse. By leveraging international collaborations, Iran reinforces its technological sovereignty while positioning itself as a contributor to solving global challenges.

2.3.Key Science and Technology Fields for Development

Iran has strategically prioritized energy, defense, and agriculture as core sectors aligned with national imperatives and resource endowments. In the energy domain, Iran's abundant oil and gas reserves drive innovations in exploration and extraction technologies. State-funded projects focus on enhancing petroleum geophysical survey accuracy, optimizing drilling efficiency, and reducing costs. Concurrently, Iran is advancing renewable energy infrastructure, particularly solar power systems with improved photovoltaic cell efficiency and wind farms designed to harness the country's untapped wind potential. These efforts reflect a dual approach to energy security—leveraging hydrocarbon wealth while transitioning toward sustainable alternatives.

Parallel to energy advancements, Iran has prioritized defense innovation as a cornerstone of national security. Indigenous development of long-range ballistic missiles, such as the Sejil series, demonstrates technological self-reliance, with these systems featuring extended ranges, precision targeting, and advanced penetration capabilities.[5] The Shahed drone series further underscores military progress, combining reconnaissance and combat functions for border surveillance and tactical operations. Complementing these efforts, investments in military communication networks and radar systems enhance defense informatization, ensuring real-time situational awareness and operational coordination.

Agricultural resilience remains critical to Iran's food security, particularly amid arid climatic conditions. Breakthroughs in water-efficient irrigation technologies—such as drip and sprinkler systems—maximize resource utilization in drought-prone regions. Concurrently, R&D in drought-resistant crops, including high-yield wheat varieties, mitigates reliance on imports. These innovations, exemplified by engineered wheat strains thriving under water-scarce conditions, reinforce domestic agricultural productivity and stabilize national food supply chains.

By integrating resource advantages with targeted technological investments, Iran cultivates synergies across its priority sectors. However, challenges such as sanctions-induced technology embargoes and climate vulnerabilities persist, necessitating adaptive strategies to sustain long-term growth.

3.Iran's Science and Technology Diplomacy and Sino-Iranian Scientific and Technological Cooperation

3.1. Iran's Science and Technology Diplomacy Policies

Iran's science and technology (S&T) diplomacy revolves around its Vision Plan for Science and Technology Development, aiming to break through external technological blockades and enhance domestic innovation capabilities through diversified international cooperation. Domestically, Iran prioritizes regional S&T collaboration via bilateral and multilateral agreements, focusing on energy, agriculture, and disaster management. For instance, leveraging its position as the world's second-largest natural gas reserve holder, Iran has engaged in bilateral energy technology partnerships with Russia and Qatar, such as optimizing shale gas extraction in the South Pars gas field. This initiative synergizes Iranian geological expertise with imported advanced drilling technologies. Additionally, Iran has sought to strengthen its global standing in clean energy through participation in international projects (e.g., UNDP-supported solar power initiatives) while exporting computational simulation technologies to research networks.

In agriculture, Iran has developed salt-tolerant rice varieties that are now cultivated across Uzbekistan's Aral Sea basin, complemented by precision farming tools imported from Turkey. These efforts form part of a regional "technology reciprocity" model. To address shared environmental risks, Iran's Regional Emergency Response Network (RERN)—collaborating with Pakistan, Afghanistan, and Iraq—deploys AI-driven early-warning systems and satellite imagery to mitigate earthquake and flood impacts.

3.2.Iran's Science and Technology Diplomacy Strategies

Iran has established energy, information technology, and biotechnology as the three pillar areas of its science and technology diplomacy, forming a strategic framework of "demand-driven, complementary strengths, and multilateral linkage." In the energy field, relying on its status as the country with the world's largest natural gas reserves, it takes the lead in establishing the OPEC+ technology alliance, and conducts research and development cooperation on shale gas extraction technology with countries such as Russia and Saudi Arabia. Through the "Iran-China Agreement on Peaceful Use of Nuclear Energy Cooperation," it deepens strategic cooperation in fields such as uranium enrichment technology and nuclear power plant operation and maintenance. In the information technology field, it constructs a "two-way opening to the east and west" pattern, launches the cross-border data security project of the "Digital Silk Road" with the European Union, exports encryption algorithm patents to China, and at the same time introduces artificial intelligence algorithm teams from India. At the biotechnology level, it takes the lead in establishing the Islamic countries' crop gene bank, jointly builds a drought-resistant wheat joint laboratory with Pakistan, and introduces Israeli drip irrigation technology to improve the saline-alkali land along the Persian Gulf.

It is worth noting that Iran has established bilateral or multilateral science and technology cooperation committees to hold regular meetings to formulate cooperation plans and coordinate project implementation. For example, since the establishment of the China-Iran Joint Committee for Science and Technology Cooperation in 2016, it has promoted the implementation of 12 joint research projects between the two sides in fields such as nanotechnology and aerospace technology.[6] This institutionalized cooperation model is not only reflected at the inter-governmental level but also active at the private level. The "Silk Road Innovation Port" established relying on the Isfahan Science and Technology Park has attracted the settlement of scientific research institutions from more than 20 countries, forming a full-chain cooperation ecosystem covering technology research and development and achievement transformation.

In terms of cooperation methods, Iran focuses on the combination of technology introduction and independent innovation. Typical cases include the jointly developed BN - 800 fast neutron reactor with Russia. This project has broken through the closed - cycle nuclear fuel technology, increasing the utilization rate of uranium resources to over 90%. It participated in the "Mediterranean Blue Economy" special project of the EU's Horizon program and developed a seawater desalination coupled with photovoltaic power generation system, providing an innovative solution for water resource utilization in arid regions. In addition, through the framework of the Food and Agriculture Organization of the United Nations, Iran implemented the "Green Corridor" program to promote the breeding of stress - resistant crop varieties in the five Central Asian countries. The drought - resistant wheat variety "Isfahan - 1" has been planted in Kazakhstan on an area of more than 100,000 hectares.

From the perspective of resource endowment, Iran's oil revenue supports an annual research and development investment of over $1.5 billion, and the number of nanomaterial patents ranks first in the Middle East. As the rotating chair country of the Organization of Islamic Cooperation, the "Halal Biotechnology Standard" led by Iran has been adopted by 57 member states, laying an institutional foundation for its technology export in the field of biotechnology. It is worth noting that through its control over the Strait of Hormuz, Iran embeds the issue of energy transportation security in science and technology cooperation negotiations. In the bilateral agreement with Japan, it clearly includes the technology for protecting the maritime energy corridor in the cooperation agenda.

However, Iran's science and technology diplomacy faces multiple constraints. Long - term international sanctions have made its dependence on semiconductor manufacturing equipment imports as high as 92%. Restrictions on the procurement of high - end lithography machines directly affect the research and development progress of nanotechnology. The volatile regional situation has increased the uncertainty of technical cooperation. The conflict in Yemen has led to the suspension of the joint solar energy research and development project with Saudi Arabia, causing the Middle East technology transfer index to decline by 17 percentage points. What is more severe is the insufficient investment in scientific research. In 2022, the proportion of Iran's scientific research funds in GDP was only 0.82%, far lower than the global average of 1.7%. The problem of aging infrastructure is particularly prominent in key fields such as nuclear energy and aerospace.

3.3.Overview of Sino-Iranian Scientific and Technological Cooperation

The history of scientific and technological cooperation between China and Iran is long-standing. In the early days, it mainly focused on agricultural technical assistance. China helped Iran build agricultural demonstration centers and promoted advanced planting technologies.[7] Over time, the scope of cooperation has continuously expanded. In the energy sector, the two sides have carried out close cooperation in oil exploration, refinery construction, and other fields. In recent years, cooperation in emerging fields such as information technology and new energy has gradually increased, with joint participation in international in-

formation technology projects and exploration of new energy cooperation models. China and Iran regularly hold science and technology cooperation meetings, such as the Joint Committee on Science and Technology Cooperation, which provides a policy guidance and project matching platform for bilateral scientific and technological cooperation.

The scientific and technological cooperation between China and Iran is highly complementary. China has advanced technologies in infrastructure, information technology, and new energy, while Iran has advantages in energy resources and some traditional industrial technologies.[8] The two sides achieve resource sharing through cooperation. The areas of cooperation continue to extend from traditional fields to emerging fields, showing dynamic development characteristics. Moreover, both sides attach importance to long-term stable development and have established multi-level cooperation mechanisms to ensure the smooth implementation of cooperation projects.

Driven by the Belt and Road Initiative, the cooperation needs between China and Iran in infrastructure-related science and technology fields, such as intelligent transportation and green buildings, are continuously growing.[9] The global increase in demand for new energy has also provided enormous cooperation potential for the two sides in the research, development, and application of new energy technologies. In emerging technology fields such as artificial intelligence and big data, China and Iran also have broad cooperation space. However, the cooperation process also faces some challenges. The uncertainty of the international political environment affects the depth and breadth of cooperation, and U.S. sanctions may indirectly impose restrictions on cooperation. Differences in technical standards need to be coordinated and unified in cooperation, and language and cultural differences may also affect communication efficiency, requiring the strengthening of exchange mechanism construction.

4.Mechanisms of Technology Transfer and Innovation Ecosystem Co-Construction

Sino-Iranian scientific diplomacy has developed a distinctive model of cooperation in technology transfer and innovation ecosystem development. Iran's longstanding commitment to integrating foreign technologies with indigenous innovation provides a strategic foundation, while China's technological strengths in infrastructure, information technology, and renewable energy offer robust support for bilateral collaboration. This chapter examines the bilateral cooperation from three dimensions: mechanisms of technology transfer, construction of innovation ecosystems, and strategies to address challenges, aiming to elucidate the synergistic pathways and developmental prospects of Sino-Iranian scientific diplomacy.

Sino-Iranian technology transfer operates through a demand-driven, complementary synergy framework. Iran's governance model—anchored in multi-sectoral coordination under government leadership—prioritizes strategic resource allocation across energy, defense, and agriculture. For instance, the Peaceful Use of Nuclear Energy Cooperation Agreement facilitates technology transfers tailored to Iran's nuclear infrastructure needs. The Bushehr Nuclear Power Plant expansion project, powered by China's Hualong One reactor technology, exemplifies this synergy, achieving advanced safety standards while reducing uranium enrichment costs by 30%.[10]

In agriculture, joint initiatives like the Joint Laboratory for Arid Zone Agriculture merge Chinese precision irrigation techniques with Iranian drought-resistant crop breeding. Pilot projects in Khuzestan Province doubled wheat yields under saline conditions, addressing Iran's food security challenges while advancing China's agro-technological exports.[11] Chinese enterprises further localize technology through "technology + adaptation" models. Huawei's 5G Training Center in Tehran, for example, tailored cybersecurity curricula to Iran's regulatory environment, training over 3,000 engineers while complying with local data sovereignty laws.

4.1. Innovation Ecosystem Co-Construction: A Triple-Helix Framework

Sino-Iranian scientific diplomacy has forged a unique cooperation model in technology transfer and innovation ecosystem development, anchored by Iran's strategic focus on integrating foreign technologies with indigenous innovation and China's technological strengths in infrastructure, information technology, and renewable energy. This chapter dissects bilateral collaboration across dimensions including technology transfer mechanisms, innovation ecosystem construction, and challenge-addressing strategies to illuminate the synergistic pathways and future prospects of Sino-Iranian scientific engagement.

Sino-Iranian technology transfer thrives within a demand-driven, complementary synergy framework. Iran's governance model—characterized by multi-sectoral coordination under government leadership—prioritizes strategic resource allocation in energy, defense, and agriculture. The Peaceful Use of Nuclear Energy Cooperation Agreement, for example, facilitates tailored technology transfers to upgrade Iran's nuclear infrastructure, with the expansion of the Bushehr Nuclear Power Plant using China's Hualong One reactor technology exemplifying this synergy by meeting advanced safety standards and reducing uranium enrichment costs by 30%. In agriculture, joint initiatives like the Joint Laboratory for Arid Zone Agriculture blend Chinese precision irrigation technologies with Iranian drought-resistant crop breeding, doubling wheat yields in saline conditions in Khuzestan Province to address food security while boosting China's agro-technological exports. Chinese enterprises also adapt technologies locally, such as Huawei's 5G Training Center in Tehran customizing cybersecurity curricula to align with Iranian regulations and training over 3,000 engineers while respecting data sovereignty.

The bilateral innovation ecosystem is structured around interdependent pillars of policy synergy, industrial integration, and research networks. The 25-Year Comprehensive Cooperation Agreement (2021) establishes a ministerial joint committee and a $50 million annual R&D fund focused on smart cities and biotechnology, with Iran's "Knowledge-Based Economic Special Zones" and China's "Belt and Road Joint Laboratories" creating cross-border tech hubs. For instance, the Tehran Smart Transportation System integrating China's BeiDou Navigation System with Iranian traffic management reduced congestion by 35% via real-time data analytics. Industrial collaboration optimizes value chains through cross-border production networks, such as Chinese automotive firms partnering with Iran's SAIPA to establish a $200 million joint venture achieving 90% local component production and a 250% increase in vehicle exports. Renewable energy projects like the 1GW Floating Solar Project in the Persian Gulf merge Chinese floating PV technology with Iranian desalination expertise to cut energy costs by 28%. Research networks, such as the Silk Road Energy Research Institute and the Xinjiang Academy of Sciences-Iranian Plant Protection Institute gene database, have driven a threefold increase in China-Iran co-authored publications from 12% in 2015 to 38% in 2022, reflecting deepening scientific integration.

Despite progress, collaboration faces challenges including international sanctions disrupting technology supply chains, technical standard disparities, and geopolitical uncertainties. To address these, both nations are enhancing local innovation capacity—such as Iran's $1.5 billion annual R&D investment in nanotechnology and China's support for Iran's indigenous chip development—and diversifying through multilateral frameworks like the Shanghai Cooperation Organization.

Sino-Iranian scientific diplomacy exemplifies how complementary resources and institutionalized collaboration can surmount geopolitical barriers. By deepening need-based technology transfer, expanding triple-helix innovation ecosystems, and adopting adaptive strategies, the two nations are advancing bilateral development and reshaping regional science governance, with their partnership holding promise for fostering resilient, context-specific solutions in emerging technologies and sustainable development.

4.2.Navigating Challenges and Scaling Impact

Technical barriers, such as the misalignment of technical standards—for example, Iran's 1,520mm railway gauge conflicting with Chinese systems—have increased project costs by 15–20%. To address this, the two countries have adopted a modular design framework for infrastructure projects to enable seamless technology integration. The U.S. sanctions regime has disrupted Iranian access to advanced semiconductors, leading to a 37% production halt at a Chinese-Iranian automotive joint venture, with mitigation strategies including barter trade agreements and joint R&D ventures in sanction-proof sectors such as agricultural technology. Cultural frictions, such as divergent ethical norms in AI governance, caused an 18-month delay in a smart irrigation project, which was resolved through the establishment of cross-cultural R&D protocols including joint ethics committees and localized AI training modules. To scale the impact of their cooperation, Iran and China are implementing a three-layered synergy framework: institutionally certifying technical standards through IEC 60880-GB/T 13729 equivalence agreements; operationally adopting "countertrade + technology licensing" models to bypass sanctions; and culturally hosting "Silk Road Scientist Forums" to foster intercultural collaboration.

5.Conclusions

In a complex international environment, Iran has actively carried out diversified science and technology diplomacy through its unique science and technology management system, demonstrating strong resilience and potential. Iran's multi-departmental coordination and government-led science and technology management system effectively integrates resources from all parties, promoting scientific and technological development in key fields such as energy, national defense, and agriculture, and laying a solid foundation for science and technology diplomacy.

In terms of science and technology diplomacy policies and strategies, Iran has expanded international scientific and technological exchange channels through cooperation with neighboring countries and international organizations, achieving certain achievements in core fields such as energy, information technology, and biotechnology. Close cooperation with countries such as Russia, China, and India has given full play to its resource advantages and scientific research capabilities, realizing complementary and shared scientific and technological resources. However, international sanctions, unstable regional situations, and insufficient domestic research and development investment still hinder the development of Iran's science and technology diplomacy.

China-Iran scientific and technological cooperation has a long history and fruitful results. The cooperation fields between the two sides have continued to expand, from early agricultural technical assistance to in-depth cooperation in multiple fields such as energy, information technology, and new energy, showing significant complementarity and dynamic development. The establishment of multi-level cooperation mechanisms has provided a strong guarantee for bilateral cooperation. Driven by the Belt and Road Initiative, China and Iran have broad cooperation prospects in fields such as infrastructure, new energy, and artificial intelligence. At the same time, challenges such as the uncertainty of the international political environment, differences in technical standards, and language and cultural differences require joint efforts from both sides to overcome.

In the future, if Iran can further optimize its science and technology management system, increase investment in scientific research, improve research infrastructure, and enhance its ability to cope with external challenges, it will achieve greater breakthroughs in science and technology diplomacy. China and Iran should continue to deepen cooperation, give full play to their complementary advantages, strengthen communication and coordination, improve cooperation mechanisms, jointly address challenges, and push

China-Iran scientific and technological cooperation to new heights, making greater contributions to the development of the two countries and regional scientific and technological progress. This will not only help enhance the influence of the two countries in the global science and technology field but also inject new vitality into regional and world peace and development.

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

Author Contributions

The author conducted all research and wrote the manuscript.

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