SCIENCE DIPLOMACY AND ADVOCACY IN A CHANGING GEOPOLITICAL ERA

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Abstract

Scientific progress from the Industrial Revolution to today's AI revolution has fundamentally transformed human civilization. In our current era of climate emergencies, global health threats, and geopolitical instability, science diplomacy and advocacy have become critical mechanisms for international cooperation and informed decision-making. This study analyzes how collaborative scientific endeavors—including the International Space Station, CERN, and IPCC—transcend political barriers, while science advocacy works to counter disinformation and integrate research into policymaking. With particular attention to Latin America and the Caribbean, the paper investigates both obstacles (environmental crises, talent migration, health disparities) and innovative solutions (regional vaccine development, Amazonian sustainability initiatives, open-access science platforms). The findings reveal that despite systemic challenges, scientific cooperation enhances both local resilience and global partnerships. The study finds that in today's divided world, science plays a vital role as a unifying force, promoting sustainable progress, fair solutions, and fostering international confidence. Embedding science diplomacy and advocacy within institutions becomes a crucial approach to transforming global challenges into shared opportunities for progress.

Keywords

Latin America and the Caribbean, Global Challenges, Disinformation, Sustainability, Scientific Cooperation

From Steam Engines to Artificial Intelligence: The Revolutionary Discoveries that Transformed Civilization

Throughout history, each century has brought transformative scientific discoveries that have shaped the course of human civilization. Over the past three centuries, key innovations and breakthroughs have not only accelerated technological advancement but also significantly influenced societal structures and daily life (Landes, 1998; 2010). These developments continue to expand the boundaries of possibility while raising important ethical considerations.

In the 19th century, industrial growth took off with the widespread use of the steam engine (Wisniak, 2007) and the invention of the internal combustion engine (Otto, 1877). Breakthroughs in electricity by Faraday and Edison (Faraday, 1846; Edison, 1880) changed how people lived and worked. At the same time, Pasteur's important discovery, that microorganisms cause both fermentation and disease, helped lay the foundation for modern medicine and industry (Berche, 2012).

The 20th century witnessed profound scientific and technological revolutions. Quantum mechanics fundamentally altered our understanding of space, time, and matter (Drummond, 2019; Camilleri, 2025), while Einstein's theory of relativity provided insights into large-scale cosmic phenomena (Sauer, 2005). The development of nuclear power marked another major milestone (Bernstein, 2023; Gu, 2018). Pioneering achievements by figures such as Turing (Fortnow, 2011), von Neumann (Eigenmann & Lilja, 1998), and the team of Bardeen, Brattain, and Shockley (Ross, 1998) paved the way for modern computers and transistors. Medical science was revolutionized by the discovery of penicillin, the first antibiotic (Fleming, 1929), and the unveiling of DNA's structure by Watson and Crick (1953). Agriculture also advanced significantly, with the introduction of mechanized equipment, improved irrigation methods, and the use of fertilizers and pesticides that led to higher crop yields and played a key role in supporting population growth and industrial development (Santos et al., 2019). Innovations like the internet (Leiner et al, 2009; Plotkin, 2014) and vaccines (WHO, 2020; McDougall, 1997) transformed everyday life, and while milestones in space exploration, including satellites and the 1969 Moon landing (NASA, 2019), vastly expanded humanity's reach and perspective.

Just 25 years into the 21st century, we are already seeing groundbreaking innovations that are transforming our world. Artificial intelligence (AI) and machine learning, such as deep neural networks and generative AI, such as ChatGPT, DeepSeek, Python and Maritaca, are making it possible to create everything from text and images to code and simulations (Cheng & Titterington, 1994; Ghosh-Dastidar & Adeli, 2009; Hagendorff, 2024; Filgueiras & Almeida, 2021; OpenAI, 2022; DeepSeek-VL Team, 2024; Python Software Foundation, 2023; Almeida et al., 2024). Advances in renewable energy sources like solar and wind, along with improvements in battery technology, offer hope for a more sustainable future (Mohtasham, 2015; Njema et al., 2024). Meanwhile, biotechnology breakthroughs like CRISPR gene editing have already been used in agriculture and human

diseases (Doudna & Carpentier, 2014; Zhang et al., 2018; Oliva et al, 2019; Frangoul et al., 2021; Gilmore et al., 2021) and mRNA vaccines highlight the incredible potential of modern science (Karikó et al., 2005; Pardi et al., 2018).

In conclusion, a quarter into the 21st century, rapid advancements in artificial intelligence, renewable energy, and biotechnology are already reshaping society, offering transformative solutions across fields such as communication, sustainability, and health.

Science Diplomacy and Science Advocacy: Distinctions and Synergies

In the 21st century, within the unprecedented exponential growth of science, technology, and innovation, science diplomacy and science advocacy have emerged as powerful tools for addressing global challenges, fostering international cooperation, and ensuring that evidence-based policies shape our collective future. Both approaches recognize that scientific knowledge goes beyond borders and that collaboration is essential to solving complex issues, from climate change and pandemics to sustainable development and technological innovation. Science diplomacy and science advocacy play a critical role in shaping effective global governance, particularly in the challenges of an evolving geopolitical landscape.

Science diplomacy refers to the use of scientific collaboration to strengthen international relations, resolve conflicts, and promote mutual understanding (Flink & Schreiterer, 2010). Science diplomacy is endorsed at distinct levels, local, national, and transnational, each with unique mechanisms and impacts. As a multifaceted discipline, science diplomacy operates across different strata, bridging scientific progress and diplomatic strategy.

1. Diplomacy for Science enables international research partnerships among countries. For instance, one of the most relevant examples of this type of international collaboration is the CERN (Conseil Européen pour la Recherche Nucléaire or European Council for Nuclear Research), established in 1954 in Geneve that maintains cooperation with its different categories of member states implementing CERN's scientific and geographical enlargement policy. Other examples: the Intergovernmental Panel on Climate Change (IPCC) was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988, which represents the United Nations body for assessing the science related to climate change (IPCC, n.d.).

2. Science in Diplomacy applies scientific expertise and data to inform and shape foreign policy decisions, such as, e.g., nuclear non-proliferation, climate agreements, pandemic preparedness and response, space exploration treaties, cybersecurity and emerging technologies, marine conservation and ocean policy, environmental monitoring and data sharing, among others (IAP, n.d.).

3. Science for Diplomacy, the use of scientific collaboration to reduce geopolitical tensions and build trust between nations, such as the International Space Station (ISS), that includes the United States of America, Russia, and Global Partners, which despite the political tensions between the US and Russia, remains a symbol of peaceful cooperation

(NASA, 2025). Another example is the Arctic Science Cooperation (USA, Russia, Canada, Nordic Countries) that facilitates joint research on climate change and shares data on melting ice and ecosystems despite geopolitical contentions (Berkman et al., 2017; Zaika & Lagutina, 2023).

Science advocacy refers to the active promotion of the integration of scientific evidence into policymaking (Pielke, 2007) and public discourse (Brownell et al., 2013). Scientists, professional societies, and non-governmental organizations (NGOs) engage in advocacy for various purposes, including:

1. Influencing legislation, such as advocating for increased research funding or the implementation of environmental regulations.
2. Combating misinformation, for instance, through public campaigns to promote vaccine adoption during the COVID-19 pandemic.
3. Safeguarding scientific integrity by opposing political interference in research and defending evidence-based practices.

Although both science diplomacy and science advocacy aim to strengthen the role of science in society, they operate in distinct yet sometimes overlapping spheres. Science diplomacy leverages scientific collaboration to build trust, foster cooperation, and address shared challenges, both internationally and within national or regional contexts. In contrast, science advocacy focuses on influencing policymaking at domestic and global levels to ensure that decisions are informed by robust scientific evidence. For example, during the COVID-19 pandemic, science diplomacy played a key role in facilitating global vaccine distribution efforts, such as the COVAX initiative (WHO, 2022; de Bengy Puyvallée & Storeng, 2022). At the same time, science advocacy worked to promote equitable access to vaccines and to combat vaccine hesitancy (Harman et al., 2021). Despite their different focuses, both approaches rely on credible scientific evidence to bridge gaps, whether between nations, in the case of diplomacy, or between science and society, in the case of advocacy.

Science diplomacy and science advocacy are two sides of the same coin: one builds bridges between nations, while the other ensures that action is guided by scientific evidence. Together, they amplify the role of science in addressing humanity's greatest challenges. Today's global challenges, such as climate change, pandemics, food and water insecurity, energy transitions, and emerging technologies like artificial intelligence, demand coordinated, science-informed responses. In an era marked by misinformation, polarization, and geopolitical fragmentation, science diplomacy and advocacy are more vital than ever. Science diplomacy fosters international collaboration and trust, while science advocacy ensures that public policies remain grounded in credible, evidence-based research. By working in tandem, these approaches help safeguard informed decision-making, promote global stability, and ensure that science continues to serve the public good.

The Contemporary Relevance of Science Diplomacy and Advocacy

As previously mentioned, the defining challenges of our era, climate change, pandemics, cybersecurity threats, food and water insecurity, and the ethical governance of emerging technologies, do not respect borders. These issues require international cooperation, data sharing, and coordinated responses that transcend national interests. Science diplomacy enables nations to work together through shared scientific goals even when political ideologies diverge.

For instance, the IPCC brings together thousands of scientists from around the world to assess climate data and provide policymakers with consensus-based reports. While countries may have conflicting economic interests regarding emissions reductions, the IPCC's scientific assessments should serve as a neutral foundation for negotiations like those seen in the Paris Agreement, even though countries are pulling off the agreement.

Similarly, during the COVID-19 pandemic, global cooperation in vaccine development through initiatives like COVAX demonstrated the power of science diplomacy. Though geopolitical competition hindered full global solidarity, scientific networks remained active, facilitating information exchange and speeding up the development of vaccines.

Science advocacy played a parallel role by fighting misinformation, promoting public health guidelines, and pressuring governments to follow the advice of scientists. Public campaigns and trusted science communicators helped build trust in vaccines and public health measures, highlighting how advocacy complements diplomacy in a time of crisis.

In recent years, international relations have been shaped by growing competition among major powers, nationalism, and a retreat from multilateralism. Tensions between countries like the United States of America, China, and Russia have led to the politicization of scientific collaboration, as seen in space exploration, 5G infrastructure, artificial intelligence, and biotechnology, among others.

For example, in 2023, rising tensions between the USA and China over technology access led to export controls on advanced semiconductors. Such restrictions risk fragmenting the global scientific enterprise and reducing opportunities for collaborative innovation. Yet despite these divides, scientists from both countries continued to collaborate on issues such as climate modeling and public health, areas where shared interests can foster dialogue even when diplomacy is strained.

Meanwhile, science advocacy becomes critical within national borders, particularly when scientific advice is ignored or politicized. In the United States, for example, debates around climate policy, pandemic response, and environmental regulation have often revealed deep divisions between scientific consensus and political rhetoric (Basseches et al., 2022).

Another pressing challenge of our time is the widespread erosion of trust in institutions, including scientific ones. Science advocacy is essential in this context. Communicating science clearly and accessibly to the public can counteract disinformation and restore trust. Scientists today must engage not only in research but also in storytelling, education,

and media outreach. Initiatives like the March for Science, ScienceDebate.org, Pint of Science, Sci-Pub, and many others aim to bridge the gap between the scientific community and the public (Scheufele, 2014).

Science diplomacy plays a crucial role in countering state-sponsored disinformation. As geopolitical actors increasingly manipulate information, scientific diplomacy fosters international cooperation to combat misinformation and promote media literacy, especially on critical issues like climate change, public health, and vaccines. Strengthening cross-border scientific collaboration helps build trust in reliable sources and ensures that the public has access to accurate, evidence-based information.

At the same time, the rise of emerging technologies, such as artificial intelligence, gene editing, quantum computing, and nanotechnology, poses both extraordinary opportunities and profound ethical dilemmas. Regulating these technologies requires not only scientific expertise but also foresight, transparency, and inclusive global governance. These goals cannot be achieved in isolation. International cooperation, underpinned by strong science diplomacy, is essential to ensure that these technologies are developed responsibly and equitably.

The shifting stance of the United States of America (USA) government toward science in recent years further underscores the importance of both science advocacy and diplomacy. As one of the world's leading science producers and a central player in global policy, USA's decisions on issues like climate change, pandemic preparedness, and emerging technologies have widespread implications. The previous retreat from multilateral scientific engagement, exemplified by the withdrawal from the Paris Climate Agreement and skepticism toward institutions like the CDC (Centers for Disease Control and Prevention) and World Health Organization (WHO), undermined global trust in science-based policy. These actions highlighted how political dynamics can jeopardize the role of science in both domestic and international governance.

However, the polarized political landscape in the USA, as well as in other parts of the world, makes these gains vulnerable. Continued science advocacy is necessary to embed scientific evidence as a nonpartisan foundation for policymaking. At the same time, science diplomacy must be strengthened to rebuild international alliances and foster cooperation on urgent transnational issues such as climate change, pandemics, and digital security.

Ultimately, the future of science-informed policy, and the global collaboration it enables, depends on the sustained efforts of both advocates and diplomats. As political landscapes shift and misinformation spreads, science diplomacy and advocacy remain essential for ensuring that science continues to serve the public good and address humanity's most pressing challenges.

Science Diplomacy and Advocacy in a Changing Geopolitical Era: The Latin America and Caribbean Perspective

In the 21st century, science, technology, and innovation are evolving at an unprecedented pace, offering transformative potential across societies and economies. Yet this progress unfolds within a global landscape marked by fragmentation, misinformation, and rising geopolitical tensions. In this context, science diplomacy and science advocacy have become vital tools, particularly in regions like Latin America and the Caribbean (LAC), where global challenges are compounded by long-standing social, economic, and institutional inequalities.

Science diplomacy can help LAC countries navigate transboundary crises, strengthen democratic governance, and elevate their role in global scientific discourse. As this region faces increasing pressure from climate change, migration, health crises, and extractive economic models, the need to integrate science into policy and diplomacy has never been greater.

Latin America and the Caribbean face complex and interlinked challenges. The region is particularly vulnerable to climate change, experiencing droughts, extreme weather, biodiversity loss, and rising sea levels. It also suffers from systemic inequality, weak health systems, and political instability. These problems transcend borders and demand coordinated, evidence-based responses.

The COVID-19 pandemic exposed deep weaknesses in the region's public health infrastructure and scientific autonomy. Yet it also catalyzed science diplomacy and advocacy in promising ways. Countries like Argentina, Brazil, and Mexico played significant roles in vaccine development, manufacturing, and distribution. These initiatives also required strong science advocacy to promote public trust in vaccines and counteract misinformation. In Brazil, where political leaders often downplayed the virus, the country's scientific community, including the Oswaldo Cruz Foundation (Fiocruz) and university researchers, played a crucial role in advocating for science-based health measures.

LAC is one of the most biodiverse regions in the world, home to the Amazon rainforest, Andean glaciers, coral reefs in the Caribbean, and vast freshwater reserves. Yet it is also ground zero for climate impacts and environmental degradation.

Science diplomacy is already shaping how countries approach shared environmental concerns. Science By and for the Amazon sponsored by the Inter-American Network of Academies of Sciences (IANAS) in partnership with other leading scientific organizations such as the Science Panel for the Amazon (SPA), The World Academy of Science (TWAS) Latin America and Caribbean Regional Partner, in 2023, together with scientists and policy makers from Amazonian countries participated in Manaus to support regional academies for Amazonian countries to work together and bring attention to the Amazon biome, focusing in four main axes: 1) Considering the Amazon as a regional entity of the Earth system. 2) The human presence and socio-cultural diversity in the Amazon. 3) Socio-ecological transformations. 4) The search for solutions for the sustainable development of the Amazon. We strongly encourage our Member Academies and partner organizations to disseminate this letter within your network (IANAS, 2023).

Science diplomacy is increasingly shaping how countries address shared environmental challenges, particularly in ecologically critical regions such as the Amazon. In 2023, the initiative "Science By and For the Amazon", sponsored by the Inter-American Network of Academies of Sciences (IANAS) in collaboration with leading organizations including the Science Panel for the Amazon (SPA), the Latin America and Caribbean Regional Partner of The World Academy of Sciences (TWAS) and the Brazilian Academy of Sciences (ABC) has brought together scientists and policymakers from Amazonian countries for a high-level meeting in Manaus. The goal was to support regional scientific collaboration and draw attention to the importance of preserving the Amazon biome. The initiative focused on four key thematic areas: 1) Recognizing the Amazon as a vital regional component of the Earth system; 2) Addressing the human presence and socio-cultural diversity within the region; 3) Understanding ongoing socio-ecological transformations; and 4) Identifying solutions for the sustainable development of the Amazon. Also, the Amazon Cooperation Treaty Organization (ACTO), comprising Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname, and Venezuela—also participated in the discussions. The meeting addressed a range of pressing issues, including scientific assessments of deforestation, water quality, and the integration of indigenous knowledge systems. The Manaus Letter was then presented to governmental authorities and ministries at the Summit in Belem. These efforts highlighted a growing recognition that science must play a central role in guiding regional diplomacy to safeguard shared ecosystems like the Amazon. The collective engagement of Academies through IANAS can provide independent, evidence-based advice for policymakers at the local, regional, and global levels on the Amazon and its impact on global environmental changes that affect food and water security, health, biodiversity, and natural disasters, among other pressing concerns.

The Inter-American Institute for Global Change Research (IAI) is an intergovernmental organization that brings together 19 countries from the Americas. It promotes collaborative research and capacity-building focused on global environmental change, providing scientific knowledge to inform policy decisions. The IAI serves as a strong example of science diplomacy in action, fostering international cooperation to address critical challenges such as climate change, biodiversity loss, and sustainable development across the region (IAI, 2025).

Latin America and the Caribbean remain underrepresented in global science output. Dependence on foreign technology and intellectual property poses a serious challenge to regional sovereignty, particularly in areas like pharmaceuticals, data infrastructure, and artificial intelligence. Nevertheless, regarding Open Science, through the SciELO network (Scientific Electronic Library Online) LAC countries provide regional journals with free global access. Originally established in Brazil in 1997, today there are 16 countries in the SciELO network and its journal collections: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador, Mexico, Paraguay, Peru, Portugal, South Africa, Spain, Uruguay, and Venezuela.

Science diplomacy can also be a soft-power tool for improving regional integration and trust in a politically fragmented continent. While Latin America does experience frequent political crises, migration surges, and deteriorating trust in institutions, with governments shutting down National Academies of Science and Universities.

In recent years, the migration of scientists and LAC has accelerated, driven by a combination of structural and political factors. Chronic underinvestment in research and development, limited career opportunities, political instability, and restrictive government policies have undermined the academic and scientific environment in several countries across the region. As a result, many highly trained professionals and aspiring researchers are compelled to seek opportunities abroad, particularly in North America and Europe, where more robust funding systems, academic freedom, until recently in the case of the USA, and institutional support enable them to pursue advanced research and career development. This ongoing brain drain not only weakens the scientific capacity of LAC countries but also hampers their long-term development and innovation potential.

Cuba is a unique case in science diplomacy. Despite being economically constrained, it has maintained a strong biotech sector and exported medical personnel and vaccines across the Global South. During the COVID-19 pandemic, Cuba developed multiple vaccines and provided them to allied countries. While this health diplomacy is politically strategic, it also reflects a long-standing investment in science for international solidarity.

Despite positive examples, challenges remain. Many countries still lack permanent science advisory bodies. Scientists often face political pressure or are excluded from decision-making processes. Funding for science is inconsistent, and international collaborations are underutilized due to bureaucratic hurdles or ideological divides.

To strengthen science diplomacy and advocacy in the region, countries need to establish national science advisory councils and ensure they are independent, transparent, and integrated into executive policymaking. Science and technology ministries need dedicated teams trained in diplomacy, negotiation, and multilateral engagement. Similarly, foreign ministries should include science attachés in embassies and multilateral delegations. Governments must commit to raising R&D spending to at least 1% of GDP (a long-standing regional goal), while fostering collaboration with universities, private industry, and civil society.

In a time of rising uncertainty, misinformation, and fragmentation, science diplomacy and advocacy are not luxuries, they are imperatives for Latin America and the Caribbean. They offer tools to strengthen national and regional resilience, elevate the region's global scientific voice, and ensure that development is guided by evidence, inclusion, and sustainability.

The LAC region has already demonstrated innovation and leadership in these areas, from regional vaccine production and climate diplomacy to open science advocacy and grassroots environmental campaigns. But these efforts must be institutionalized, funded, and connected across borders to achieve lasting impact.

However, across all regions, these efforts must be institutionalized, adequately funded, and connected across borders to achieve a lasting impact. The challenges we face, climate change, pandemics, food security, energy transition, and misinformation, are global and require coordinated scientific diplomacy and advocacy to overcome. By embracing science as a tool for cooperation, communication, and empowerment, countries worldwide can transform today's crises into opportunities for transformation. Ensuring that science remains at the heart of policy and development is vital to building a just, inclusive, and sustainable future for all humanity.

Conclusion: Science as a Unifying Force in an Age of Division

From the steam engine to artificial intelligence, scientific progress has continually reshaped civilization, pushing the boundaries of what is possible while raising profound ethical and geopolitical questions. As we navigate the complexities of the 21st century, marked by climate crises, pandemics, technological disruption, and geopolitical fragmentation, science diplomacy and advocacy have emerged as indispensable tools for fostering cooperation, ensuring evidence-based policymaking, and safeguarding global stability.

The historical trajectory of scientific advancement demonstrates that innovation thrives in environments of collaboration, not isolation. Whether through international partnerships like CERN and the International Space Station or regional efforts such as the Amazon Science Initiative and Latin America's vaccine diplomacy, science has repeatedly proven its ability to bridge divides where politics fails. Yet, as recent challenges, from vaccine nationalism to AI governance debates, have shown, scientific progress alone is not enough. It must be accompanied by robust advocacy to combat misinformation, defend scientific integrity, and ensure that knowledge translates into equitable policies.

For Latin America and the Caribbean, the stakes are particularly high. The region faces intersecting crises, environmental degradation, economic inequality, brain drain, and political instability, that demand science-driven solutions. Yet, it also possesses immense potential, from its biodiversity and scientific talent to its growing role in global research networks. By strengthening science diplomacy and advocacy, LAC nations can amplify their influence, secure sustainable development, and contribute to a more just and cooperative world order.

Finally, the lesson of history is clear: science is most powerful when it serves as a universal language, transcending borders and ideologies. In an era of polarization and uncertainty, the integration of science into diplomacy and policymaking is not just an academic exercise, it is a necessity for survival. By championing evidence-based collaboration, fostering public trust in science, and ensuring that innovation benefits all of humanity, we can harness the full potential of scientific discovery to build a more resilient, equitable, and peaceful future.

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