SCIENCE DIPLOMACY AND SUSTAINABLE DEVELOPMENT: PERSPECTIVES FROM LATIN AMERICA

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EDITORIAL
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Editorial: Science Diplomacy and Sustainable Development: Perspectives From Latin America

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Editorial on the Research Topic

Science Diplomacy and Sustainable Development: Perspectives From Latin America

The current times present humanity with challenges that require actions beyond multidisciplinarity. They demand a transdisciplinary approach that collaborates scientific knowledge, policy, business dynamics and ancestral wisdom for solutions. In transdisciplinarity, Science Diplomacy (SD) is a specialty that fosters the engagement of diverse disciplines and stakeholders in the interface of science and foreign policy to convey a positive impact on societies and their inhabitants. This is particularly relevant in realities such as those in Latin America, where the pursuit of sustainable development for present and future generations posits a critical emphasis on respecting the planet and its resources. It is in this regard the Research Topic: Science Diplomacy and Sustainable Development: Perspectives from Latin America aims to explore relevant discussions on the need for science to be conceived internationally for sustainable national and global solutions. This is paramount because it enables actors from different countries and regions to engage in collaborative efforts towards shared objectives in seeking sustainable development, while working towards the 2030 sustainable development agenda. By bringing these issues to the fore it intended to balance studies that have been emerging from and concentrating on the European and North American focus. It is necessary to establish that the mechanisms to advance sustainable development depend on the characteristics of each territory. Therefore, for Latin American and Caribbean region, considering aspects such as communication, cultural belonging, indigenous wisdom from native populations, and gender could be beneficial in the advancement of knowledge and their effect on improving the lives of its communities.

The articles published as part of this Research Topic show the plurality of SD initiatives, the multiple challenges they face and the limits for implementation. These 14 articles can be divided into four groups. The first group deals with SD institutionalization strategies in the Latin American context. Science Diplomacy in Latin America and the Caribbean: Current Landscape, Challenges, and Future Perspectives (Soler) describes the diverse approaches, policies and practices adopted by Latin American and Caribbean countries at the national, sub-national, and regional levels. By documenting and illuminating best practices in the region, this paper further seeks to balance the perspective that has so far been largely concentrated on the regions of Europe and North America and contribute to future efforts and strategies for the development of sustainable science diplomacy mechanisms at the national, regional, North-South and South-South levels. In addition to this discussion, The Institutional Building of Science and Innovation Diplomacy in Latin America:

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toward a comprehensive interdisciplinary approach and analytical typology (da Silva, et al.) proposes, from a qualitative perspective and a multilevel typology, categories for the analysis of the emerging experiences within the framework of Science and Innovation Diplomacy in Latin America. Thus, providing a broad framework that can be used at various levels and sectors. In turn, Closing the Gap Between Emerging Initiatives and Integrated Strategies to Strengthen Science Diplomacy in Latin America (López-Vergès et al.) elaborates on the emerging efforts and mechanisms to bridge the gap between scientists and policymakers at the national and regional level. Based on national experiences, the paper proposes a way forward so that Latin America can leapfrog beyond disjointed training of individuals into integrated institutional strategies that can harness the tools of science diplomacy to enhance science-informed multilateral cooperation and enable more effective science-informed policymaking.

The second set of articles deals with discussions concerning policies, capacity building and good practices developed in emerging countries. The papers portray an interesting set of case studies, particularly from Central American countries. Institutional Capacity for Science Diplomacy in Central America (Jarquin-Solis and Mauduit) reveals several public management challenges stemming from the institutional disparity and complexity of the region, already marked by significant asymmetries of human development between the various countries. Highlighting and understanding such challenges may be helpful in developing meaningful strategies around science diplomacy for countries in the central America region. Already in turn, Science Diplomacy in Emerging Economies: A Phenomenological Analysis of the Colombian Case (Echeverría et al.) asserts that SD actors in Colombia are scattered, practices strongly related to traditional cooperation diplomatic activities are fragmented and call attention to the need to give a function to SD for capacity building. Therefore the authors conclude that better global intermediation and the development of new knowledge, in particular in promoting SD abilities in the scientific community would enhance the interaction between science and policy.

Focusing on the Ecuador experience, Science Diplomacy in Ecuador: Political Discourse and Practices Between 2007 and 2017 (Bonilla et al.) points out the different implications from the SD perspective in Ecuador; particularly, reflecting on the consistency between the political rhetoric and the policy implementation. Evidence presented in this article suggests that the political discourse materialized into concrete Science, Technology and Innovation (STI) policies that could partially explain positive transformations in various aspects of the STI context in Ecuador. Institutional strengthening, international mobility (inward and outward), increased scientific output, and foreign policy practices involving SD (which can be traced in the studied period 2007–2017) have all contributed towards positive transformations. Showing the process of strengthening and developing Panama's scientific ecosystem, Science Diplomacy as an Umbrella Term for Science Advisory in Public and Foreign Relations in Small Developing Countries: The Case of Panama (Gittens et al.) presents the main public institution in the country–the National Secretariat for Science, Technology and Innovation (SENACYT)—and its role in promoting research. Furthermore, SENACYT Panamá is recognized as pioneering the importance of training young scientists in communication, relationship and leadership skills in SD. Ocean Science Diplomacy (Polejack and Fernandez Coelho) sets out how Latin America and the Caribbean seek, despite the limitations in terms of access to technology, to conduct marine scientific research in order to take advantage of the opportunities of the blue economy. Based on the United Nations Convention on the Law of the Sea, the paper seeks to discuss the transfer of marine technology to developing countries and thus advance their knowledge of this reality and promote their sustainable development. Finally, Decolonizing Science Diplomacy: A Case Study of the Dominican Republic's COVID-19 Response (Mencía-Ripley et al.) discusses a case of how science diplomacy and a relatively new law fostering public-private partnerships allowed a university to play a major role in public health response while generating knowledge to inform public policy decisions in an unprecedented manner in the Dominican Republic. In the case, SD is discussed in the context of decolonization and the importance of the local gaze when creating academic partnerships in the context of global health emergencies.

The third set of articles seeks to debate aspects related to the education and career of researchers from Latin American and Caribbean countries, with special emphasis on the issue of gender, analyzing the participation of women in the scientific community. Science diplomacy for climate action and sustainable development in Latin America and the Caribbean: How important is the Early Career perspective to New Governance? (Cuellar-Ramirez) collects a series of examples of the progress, best practices, gaps, challenges and solutions. The author does it from the perspective of Early Careers Researchers (ECRs) and undergraduate and graduate students, highlighting what it has been done to engage scientists in society-policy-science interaction for sustainable development agenda and climate action in Latin America and the Caribbean. The case of Call to Action: Supporting Latin American Early Career Researchers on the Quest for Sustainable Development in the Region (Lopez-Verges et al.) encourages reflection on the challenges that the ECRs in Latin America and Caribbeans Countries experience. By considering these challenges and actively participating in studies about ECRs, she proposes the creation of strategies to better support the next generation of science change-makers in the region. The success of this study required collaboration between ECR organizations and policymakers, and therefore harnessing the human capital that ECRs-LAC represents is crucial for the region to meet the United Nations (UN) 2030 sustainable development goals. Looking for the gender perspective, Participation in Communities of Women Scientists in Central America: Implications From the Science Diplomacy Perspective (Bonilla et al.) explores the experiences of women scientists participating in communities of Guatemala, El Salvador, Honduras and Panama, and attempt to systematize the challenges and opportunities derived from such activities. The

findings of this study revealed few cases of community building experiences among women scientists within the studied countries. Evidence also showed the emergence of shared patterns in terms of barriers and disincentives to participating in such communities. Therefore, offering explanation for the lack of participation of women scientists in collective initiatives in Central America.

Finally, the fourth set of papers deals with discussions related to the communication of science, from the perspective of building bridges with the DS debates. The first one, Bringing Policymakers to Science Through Communication: A Perspective From Latin America (Pulido-Salgado and Castaneda Mena), aims at providing some recommendations to build bridges between science and decision-making parties through communication, and by exploring how Latin American diplomats and policymakers engage with scientific knowledge. In turn, Latin American Network for Scientific Culture (RedLCC): A Regional Science Communication Initiative (Moronta-Barrios et al.) presents an analysis of blogs and social media platforms, that are specifically open for addressing information about science to citizens in the Latin America, and are easily accessible resources. In addition, the Latin American Network for Scientific Culture (RedLCC) is highlighted as one of the regional science communication initiatives. It brings together regional scientists that communicate science for Latin American communities, and consequently nurtures the "Science for Diplomacy" dimension of SD. Thus, the communication mechanisms for Science Diplomacy and Sustainable Development are essential and strengthening them progressively could contribute to effective science communication.

The co-editors are convinced that these articles can contribute to future efforts and strategies for the development of sustainable science diplomacy mechanisms at the national, regional, North-South and South-South levels. We believe that a major contribution of the Research Topic is the inclusion of the different approaches, policies and practices adopted by Latin American and Caribbean countries at different levels. In addition, this Research Topic contributes to increasing the visibility of SD studies in the scope of Latin America, allowing for counterbalancing the emphasis, focus and narratives that studies from the regions of Europe and America imprint on DS studies. We look forward to seeing the growth of the field of Latin American studies in science diplomacy.

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OPINION
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Decolonizing Science Diplomacy: A Case Study of the Dominican Republic's COVID-19 Response

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The COVID-19 pandemic forced healthcare systems globally to handle a dramatic surge in healthcare utilization while also taxing available testing resources. In the context of healthcare systems in Latin America and the Caribbean, COVID-19 added to the existing burden of infectious diseases related to endemic infections such as arboviruses and HIV. In the Dominican Republic, testing is supplied mostly by the private sector and a national public laboratory. The surge in testing demands laid bare a lack of installed capacities both in laboratory facilities and equipment and trained staff in molecular biology laboratory procedures. This article discusses a case of how science diplomacy and a relatively new law fostering public-private partnerships allowed a university to play a major role in public health response while generating knowledge to inform public policy decisions in an unprecedented manner in the country. Science diplomacy is discussed in the context of decolonization and the importance of the local gaze when creating academic partnerships in the context of global health emergencies.

Keywords: COVID-19, Dominican Republic, decolonial, case studies, higher education managament

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INTRODUCTION

Broadly defined, science diplomacy allows academic actors to participate via research and other academic endeavors in various state programs and initiatives that generally have a global focus (Ruffini, 2020). In the context of the Madrid Declaration on Science Diplomacy, this is understood as a series of practices in which science, technology, and foreign policy meaningfully interact (Young, 2020). This approach assumes that science diplomacy is more effective than traditional diplomatic approaches because it equally satisfies all involved stakeholders' interests, including governments and non-governmental entities and that the objectives of these efforts have broad political benefits (Young, 2020).

Global issues addressed by science diplomacy can span from environmental issues to global health concerns, and most recently, the Severe Acute Respiratory Coronavirus-2 (SARS-CoV-2), which is the causative agent of the Coronavirus Disease-19 (COVID-19) pandemic. As stated by Young (2020), "the pandemic, like other global challenges, is both knowledge-intensive, in that it requires engagement with scientific knowledge for effective policymaking, and cross-border, in that it is not solvable by a single country acting alone" (p. 1).

In this sense, the COVID-19 pandemic has provided fertile ground for science diplomacy and scientific collaboration in general, as evidenced by the elimination of paywalls to access COVID-19 related data as well as the rapid publication of papers. For example, according to the WHO's Global

research database, as of November 26, 2020, there are 100,562 articles related to COVID-19, probably one of the most researched topics in the timespan of months. These unprecedented collaborative efforts to understand and fight the virus have resulted in articles in which one out of five articles is written by researchers from different countries, fostering what Lee and Haupt (2020) refer to as *scientific globalism*. It should be noted, however, that linguistic barriers for scientists from non English speaking countries remain. Another example of the benefits of science diplomacy is the Vaccine Alliance (GAVI), a partnership that brings together donor and implementing country governments, research agencies, international organizations, vaccine manufacturer and NGOs, which together with the WHO and Coalition for Epidemic Preparedness Innovations lead the COVAX initiative to support the development and manufacture of COVID-19 vaccines (WHO, 2020).

However, developing nations in the Global South and the poorest communities in developed nations have borne the heavy brunt of this disease, with some suggesting it has led to a loss of gains made in achieving the Millenium Development Goals (Mejía et al., 2020), and deviating funding allocated for neglected tropical diseases (Molyneux et al., 2020), and older pandemics afflicting most-at-risk populations like HIV, Tuberculosis, and Malaria (de Souza et al., 2020). According to the United Nations Development Program (UNDP), developing countries are expected to have income losses that would exceed 220 billion, leading to further social and health challenges (IMF, 2020). As such, science diplomacy, when directed by developed nations alone, can replicate colonial structures that continue to ignore the needs of developing nations and silences voices from countries historically ignored by the scientific community. However, science diplomacy continues to assume an equity that breaks with traditional colonialist frameworks that have dominated international research collaborations, especially in global health (Lawrence and Hirsch, 2020).

Science diplomacy requires symmetrical relationships between academic institutions and in-country legal frameworks that can support meaningful collaborations. In the Dominican Republic's case, where there is low private sector investment in research and development, a new law fostering public-private partnerships allowed an academic institution to work with the state, an international NGO, and an international research laboratory, supported by government entities in both the Dominican Republic and Italy. This multi-sectorial approach allowed for creating a comprehensive COVID-19 response program led by a local university that understood the local context and harnessed community engagement to provide critical data from and by a developing nation. This kind of partnership differs from traditional cooperation initiatives since it encourages and expects local knowledge to inform the methodology, processes, and policy recommendations resulting from the projects, increasing relevance and local ownership of the knowledge that is being produced. The opportunity to participate as equals in global scientific networks is particularly relevant for researchers in developing countries in order to guarantee that the particular needs and challenges will be taken into account.

CASE STUDY

Universidad Iberoamericana (UNIBE) is a private, not-for-profit university located in the Dominican Republic's capital, with a long-standing tradition of training in health and behavioral sciences. In 2017, UNIBE built the Tropical Medicine and Global Health Institute. The institute's equipment was donated thanks to a competitive grant designed to equip laboratories worldwide, but most specifically those in Low-Middle Income Countries (LMIC). This initiative, Seeding Labs, was created in order to relocate laboratory equipment from mostly north-based universities. Equipment that Seeding Labs allocates to developing countries can be donated by manufacturers as well as universities with surplus equipment. The Seeding Labs initiative has been running for the past 10 years, and for the first time (2017), a local university applied and was granted basic equipment and tools to set up a benchmark laboratory aimed primarily at the study of arthropod-borne diseases like Zika, Chikungunya, and Dengue viruses. This equipment was fundamental in developing a scientific hub and the first of its type in the country, providing the platform for future endeavors, including generating knowledge in case of future epidemics. Seeding Labs and its effort to strengthen developing countries' research capacities is an example of the emergence of new forms of cooperation in what Appe (2018) describes as a "post-aid world." The Dominican Republic, as many other Latin American countries, has experienced a significant reduction in aid from traditional donors during the past decades, and as many others like Brazil, Mexico, Colombia and Ecuador is witnessing and promoting civil society-led initiatives based on knowledge transfer, capacity building, and more horizontal relationships.

In the years between obtaining the initial laboratory equipment and the COVID-19 pandemic, the university made a substantial investment in its research infrastructure that included: improvements in human resource policies and compensation to attract and retain researchers, continued investment in infrastructure, creation and improvement of institutional policies and governing bodies related to intellectual property, ethics, and research management, and inserting research across academic disciplines at the university. This last step is critical, as Dominican higher education has historically focused on professional degrees with little research focus. These research specific initiatives were complemented by existing internationalization and continuing education opportunities already available at the University.

By the time the first SARS-CoV-2 infections were detected in the Dominican Republic, the Institute's molecular biology laboratory had the necessary staff and equipment to join the government's testing efforts. For example, BSL-3 pathogen management training had been conducted in collaboration with a US based university. In addition, prior to the declaration of the state of emergency provoked by the COVID-19 pandemic, the Dominican congress passed a new

law providing the legal framework for public-private collaboration in prioritized areas affecting the country. Because of this law, a team of scientists working at the institute identified the equipment, tools, and reagents required to increase diagnostic capacity along with scientific communications and communicated these needs to the government. Effective communication was a crucial aspect of the strategy as the country continues to grapple with pervasive media presence of COVID-19 cures that have no proven efficacy and which are prescribed without regulation (Tapia, 2020). As the university was communicating these needs and developing its strategies, the government was simultaneously working with the private sector in order to obtain more equipment and reagents. Once the public-private collaboration between the university and the government initiated, automatic platforms for rapid diagnosis of SARS-CoV-2 infection in hospitals and community-based settings were set up at the institute and a systematic approach for delivery of results and data analysis was deployed in a record time of three months. This led to the study that sequenced the genome of the country's circulating virus, a collaboration with an international partner in Italy.

DISCUSSION

The perspectives of science diplomacy from the Global South must be visible in academic literature to provide a complete perspective of the challenges and benefits associated with science diplomacy, especially in global health crises. Sharing these experiences as other Latin American countries like Brazil has done (Riveiro and de Freitas Lima Ventura, 2019) can also foster much needed regional cooperation among Global South countries that may share substantial similarities in terms of legal, healthcare, and academic systems. Several authors (Quadir, 2013; Beleboni, 2019) state that South-South cooperation, which is often knowledge-based, creates conditions for countries to strengthen local capacities and design context-adapted strategies. This model moves away from the conventional, top-down conditionality-driven aid approach and can become a more effective strategy to foster sustainable development.

For these efforts to become sustainable and genuinely address the pressing, systemic problems of the South, the logic of cooperation, regardless of the partners involved, must be transformed. As Chisholm and Steiner-Khamsi (2009) argue, most often, these initiatives, financed by international donors, are conceived in an increasingly standardized and prescriptive environment that leaves scarce room to incorporate the unique perspectives and challenges required for findings to be adequately relevant for the South. The renovated recognition of the importance of science and academia's role in finding solutions to global problems evidenced by COVID-19, is promising in the South, where many universities are working hard to conduct research that informs public policies. Several authors, including Xu (2020), argue that we might be "at the crossroads of our past, present, and future" (p. 29) with regards to redefining future global research, and we add scientific diplomacy.

For low and middle-income countries, investment in research infrastructure is quite onerous, requiring governmental and private collaborations. Every year there are re-emerging or emerging pathogens, global warming adds to these challenges, and as such, systems are constantly under pressure, and health infrastructures exhausted. Provision of investment in basic science research programs, training, *avant-garde* molecular equipment, observatories, and resilient institutions led by the South, provide an answer to future outbreaks and emergencies. This global crisis might be the driver of a new proactive response in which South-South collaboration will be motorized, and the colonial North-South scientific relationship might be revisited.

In order to adequately face current and future health and economic challenges, developing countries need to increase investment in research and development and promote international research cooperation. These are also signaled as basic prerequisite for establishing technology sovereignty, a concept described by Edler and colleagues (2020) as "the ability of a state or a federation of states to provide the technologies it deems critical for its welfare, competitiveness, and ability to act, and to be able to develop these or source them from other economic areas without one-sided structural dependency" (p. 8). Science diplomacy and its underlying principles and procedures to foster initiatives that address global issues, must incorporate clear guidelines in order to promote and preserve technology sovereignty, ensuring sates' capacities to remain (or become) competitive, provide adequate public services, and efficiently managing current and future crisis.

In the developing world, universities need to play a major role in strengthening international cooperation, including South-South collaboration, as they have historically looked northward for academic mobility, dual degree programs, and research collaborations. They may lead the way by doing more than just providing critical perspectives to this approach, but by actively changing internationalization policies, priorities, and indicators. Creating and increasing participation in research networks and development initiatives based on the principles of mutual learning, collaborative problem solving and co-creation of innovative technologies and expertise, as discussed by Abdenur and Estevão Marques da Fonseca (2013) are some of the mechanisms that researchers and policy makers must promote in order to challenge the current health, economic and social crisis and foster sustainable development.

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OC, and JJ had the original idea for the article. A-MR and R-PR, JJ, and OC conducted the literature review and wrote portions of the manuscript. R-PR provided expertise and insights from field work during COVID-19. A-MR edited the final version of the manuscript.

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OPINION
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Latin American Network for Scientific Culture (RedLCC): A Regional Science Communication Initiative

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INTRODUCTION

Scientific communication has been growing strong worldwide in the past decades. The use of modern data analysis tools to fine-tune its content, strategy, and effectiveness, together with the significative rise of social media, have contributed to such significative growth (Kappel and Holmen, 2019). Social media (such as blogs and microblogging) are powerful engines greatly incorporated into our daily lives for capturing information and as a social tool. As such, they are already being exploited for learning, discovering, searching, storing, and sharing knowledge (López-Goñi and Sánchez-Angulo, 2018). Research has shown that online media use increases scientific knowledge (Cacciatore et al., 2014; Su et al., 2015) and positive attitudes toward science (Dudo et al., 2011) therefore enhancing the learning and science process skills. Such scientific knowledge is a critical resource that enables political actors to inform and legitimate political decisions, and it is also important for non-scientific audiences in terms of forming public opinion about important political issues (Huber et al., 2019). Moreover, previous work has demonstrated that democratic societies that are scientifically literate make equitable choices regarding science-related policy issues (European Commission, 1995; Rudolph and Horibe, 2016). Thus, according to Márquez and Porras (2020), effective science communication and science literacy are socioeconomically imperative for all societies. At the same time, Science Communication can serve various diplomatic purposes. Particularly, science popularization initiatives, even when not targeted to policymakers or diplomats, can both raise awareness about international scientific cooperation and about locally produced science and technology which could be highly overlooked (Leach, 2015).

English is currently the lingua franca of science. Currently, 98% of publications in science are written in English (Ramírez-Castañeda, 2020). This has facilitated the dissemination of knowledge across boundaries, but at the same time, the hegemony of English in science promotes and enforces the imposition of just one cultural point of view over others (Márquez and Porras, 2020). Because of that, generating science communication multilinguistic alternatives promotes diversity and creates culturally relevant content.

Science communication in Spanish is especially imperative in Latin America. The intrinsic functional illiteracy, framed in the lack of economic and educational resources, inequality, poverty, political and social instability, are historical challenges that keep this region from unleashing its full

potential (UNESCO, 2020). Moreover, and due to these issues, Latin America faces a human capital flight crisis, in which a high percentage of the individuals pursuing higher academic education end up emigrating and learning a second language. This is reflected in a marked lack of availability of educational resources in Spanish addressed to Latin American communities.

Nevertheless, there have been efforts to build remote networks of Latin American scientists and science communicators that come together to counteract this effect. Three renown projects, different in nature, can be used as examples. First, the RedPop (Latin American and Caribbean Network for the Popularization of Science and Technology https://www.redpop.org) is a network of centers and programs created in 1990 at the request of UNESCO's program for Science, Technology and Society (Massarani et al., 2015). It encompasses around 80 science communication projects in different media platforms, but also science museums, interactive science centers, natural history museums, environmental parks, zoos, botanical gardens, and aquariums. Second, the bilingual science communication portal Latin American Science (www.latinamericanscience.org) publishes pieces written by scientist and science writers for the public both in Spanish and English-speaking countries. It focuses on regionally produced research, science policy and science-related stories from the region. And third, the Journal of Science Communication JCOM América Latina (https://jcomal.sissa.it/jcomal/index.jsp), an open access journal focused on science communication in Latin América and publishing contributions in Spanish and Portuguese (Weitkamp and Massarani, 2018). Still, more opportunities need to exist in term of communicating science with regional relevance.

Blogs and social media platforms, which are especially open and easily accessible resources, have fantastic potential to address this gap since it is allowing information and education to reach every home to an unprecedented extent. One of these regional initiatives, the Latin American Network for Scientific Culture (RedLCC), brings together regional scientists that communicate science for Latin American communities and, in consequence, also nurtures the "Science for Diplomacy" dimension of Science Diplomacy.

THE LATIN AMERICAN NETWORK FOR SCIENTIFIC CULTURE

The RedLCC (by its acronymous in Spanish Red Latinoamericana de Cultura Científica) gathers efforts for the dissemination of science and technology carried out by a group of Latin American scientists. They aim to serve as a link between scientific activity and society. As a committed, professional, multidisciplinary, and multinational initiative, the Network offers quality and culturally relevant scientific information for the non-scientific audiences in Latin America. From their different disciplines and concerns, the scientific communicators intend to restore the value of science as a fundamental part of the Latin American human cultural heritage.

The RedLCC's original founders virtually met for the first time when contributing to a Twitter hashtag in July 2012. Their common interest and passion for science communication using blogs, motivated them to join efforts and create the foundational Latin American Network of Scientific Blogs. Based on agreed statutes, which ruled the accession, permanence, and the task distribution among the members, the Network grew and agglutinated up to 22 Latin American scientific blogs within the following few years.

By November 2016, the tremendous growth of members, joining requests, and especially the raising of alternative science communication channels and web resources beyond blogging, drove a re-foundation of the Network. To adapt to the new digital environment in science communication the Network's mandate was changed, and the Latin American Network for Scientific Culture was established. Once the statutes were accordingly updated, not only blogs but other science communication channels can be part of the Network. As such, the Network expanded and diversified its information format and structure.

The RedLCC is a regional, multidisciplinary, and grassroots initiative that brings science to the non-scientific public. To date, the Network is voluntarily composed of 16 initiatives led by scientists from eight countries (**Figure 1**), who recognize the cultural background of their target community. Therefore, the RedLCC members employ culturally relevant expressions, metaphors, and storytelling approaches for creating emotional connections and engaging with various audiences. With this strategy to support science dissemination efforts in languages other than English, this Latin American initiative could effectively lower the barriers of access to knowledge and promote the interest in science.

There is a growing community around the RedLCC. The Network's blog (http://www.redlcc.org/) accumulates 116,670 visits from 109 countries to date, being 2020 the year with more visitors (an average of 80 daily visits). These numbers are greatly surpassed if the individual statistics of members are considered: a total of 1,435,404 accumulated visits are reported by all members. On the other hand, on Twitter (where all members are present and firmly active) @RedLCC is followed by 4,013 users, of which the 97.1% are real followers. It is estimated that the 58.3% are based in the Americas and Spain, the 64.4% uses Spanish as their primary language, and that for each woman follower there are 1.7 men followers. These metrics inform about the trust in the Network and serve for future improvements in the communication strategies.

The RedLCC provides direct access to scientific information directly posted by trusted scientists, strengthening public engagement with news posted by people they trust. Audiences are more likely to trust and share science news and content on social media because they are posted by a reliable source, helping also to prevent fake news that misinforms or deceive readers. By bringing together trusted communicator scientists in one place, the RedLCC's members are constructing a reference platform in the region for strengthening a regional scientific literacy, also nurturing the traditional communication channels in our region and the dynamics that are commonly used in journalism. Especially during the current COVID-19 crisis, the need for having robust, fast-responding networks to provide high-quality scientific information, news and educational content via online

A

	RedLCC member	Short description	Main URL
1	AcercaCiencia	Ibero-American education and scientific outreach platform	https://www.acercaciencia.com/
2	Átomos de Locard	Podcast with comments on the application of Science in court	https://soundcloud.com/vicente-torres-924275927
3	Braeunerd	Uses photography to make science and conservation more accessible and entertaining	https://www.braeunerd.com/
4	Ciência em Revista	Dedicated to valuing Brazilian scientific journals by means of scientific dissemination	https://www.blogs.unicamp.br/cienciaemrevista/
5	Cosmotales	Blog covering topics of Astronomy and Space Exploration	https://cosmotales.co
6	El asa de Henle	Blog about Biology and Histology	https://elasadehenle.wordpress.com/
7	Felix Moronta	Personal blog for communicating Microbiology, Biotechnology and Agriculture	https://felixmoronta.pro
8	Física Martín	Personal blog about Physics, Physics Education and Science Communication	https://fisicamartin.blogspot.com/
9	Fundación Persea	Produces culturally relevant scientific content as blog posts and podcasts	http://www.fundacionpersea.org/
10	Historias Cienciacionales	A podcast where Spanish-speaking scientists talk about their latest research	https://historiascienciacionales.tumblr.com/
11	Mel Nuesch	Videos of science fun facts, lectures, interviews scientists	https://yotube.com/melnuesch
12	Primer Fotón	Blog and podcasts about Astronomy and Computer Science	https://primerfoton.cl
13	Sinápticas	Cultural magazine merging Science and Philosophy in bilingual format	https://sinapticas.com/
14	SobreCiencia	Scientific journalism on blog, radio, and TV	https://www.sobreciencia.uy/
15	Tuyuyo Científico	Blog about biological phenomena	https://tuyuyocientifico.wordpress.com/
16	Zemiorka	Blog about Astronautics and the history of Space Exploration	http://zemiorka.blogspot.com/

B

FIGURE 1 | The Latin American Network for Scientific Culture (RedLCC). **(A)** List of the 16 members that compose the Network, in alphabetical order, by December 2020. A brief description of each one and the URL for accessing their content are shown. **(B)** The geographical origin of each of the initiatives with their scientific disciplines.

services has been proven to be of the utmost importance, not only to synchronize people's actions and efforts to work together toward maintaining safe public health, but also to highlight the crucial role of scientific research and its global impact on society.

Taking advantage of the increased connectivity of millions of citizens during 2020, new initiatives have emerged that articulate a common interest of our members to strengthen their relationship with different non-scientific actors in society. By using mass dissemination channels as well as webinar platforms, members reported the organization of live streaming events and conferences (e.g., Ciencia Viral, Maratón Cósmico, or COVID-related webinars) to reach those citizens eager for accurate and reliable information.

It is important to underline that the scientific communication activities carried out by the Network's members are not based on digital media only. Many of them report several local activities in their communities. Scientific demonstrations in schools or public places, interviews in local media (TV, radio, and newspapers), astronomical events, master classes, or participation in the editing of school and university texts are part of these activities. These offline actions often have a profound impact on the non-scientific public that has not been engaged with the Network digital media.

Together with the other regional initiatives (such as RedPOP, LatinAmericanScience, or JCOM América Latina), the RedLCC has emerged and established as a reliable source of scientific information and scientific engagement with culturally relevant content. As such, it could also inform policy-related areas about relevant scientific outputs from the region. In the light of the Sustainable Development Goals (SDGs), the Network is taking actions to address directly specific targets within the SDG #4 Quality Education, and indirectly transversal targets.

The role of the RedLCC in Science Diplomacy can be characterized by a framework that describes the contribution of science popularization initiatives to diplomacy (Leach, 2015). Not all science communication projects need to engage with policymakers or with diplomats for them to contribute to soft powers in the region. Specifically, we identify that our work within the RedLCC can serve two diplomatic purposes. First, it raises awareness of outcomes of large-scale international projects, and, mainly, of the participation of Latin American researchers in these projects. Second, it encourages high levels of scientific literacy, awareness, and dialogue among Latin American non-scientific audiences, specially about the scientific work made by regional scientists. These activities leverage public support for regionally produced science and technology, which in turn can be used by regional institutions as a "Science for Diplomacy" tool to advocate for Science Diplomacy.

CONCLUDING REMARKS

The RedLCC is a coordinated and organized regional effort lead by Latin American scientists for strengthening the scientific culture in the region. It is a social-oriented initiative that makes science accessible for many citizens linked to online social media. By communicating the findings, methods, or nature of research to audiences other than the scientific community, the Network encourages high levels of general scientific literacy, awareness, and dialogue about science and technology in Latin America. Therefore, citizens and political actors are empowered to make inform decisions. Consequently, the RedLCC encourages and reinforces agendas of science cooperation backed by both the non-specialized public and the scientific community engaged in science communication. Considering the regional and global challenges to be addressed, especially under the beginning of the Decade of Action to deliver the SDGs, the RedLCC acquires a key role that could contribute not only to enhance the scientific culture in the region but also nourishing soft power resources that have the potential to produce diplomatic outcomes.

AUTHOR CONTRIBUTIONS

FM-B conceived the presented Opinion article. All authors discussed the content and contributed to the final manuscript.

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Closing the Gap Between Emerging Initiatives and Integrated Strategies to Strengthen Science Diplomacy in Latin America

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Science diplomacy is a fast-growing field of research, policy, and practice dedicated to understanding and reinforcing the connections between science and international affairs to tackle national, regional, and global issues. By aligning science and diplomacy, countries can attract talent, strengthen their national research ecosystems, provide avenues for participation of scientists in policy, and coordinate integrated solutions to challenges with technical dimensions. While Latin America has a long tradition of bilateral and regional cooperation, science still plays a marginal role in foreign policy, as has become evidenced by the response to the COVID-19 pandemic. With few exceptions, Latin American nations have a relatively immature science, technology, and innovation ecosystem, compounded by low public and private investments in research, coexisting with profound socio-economic inequalities, and large vulnerable populations. Such challenging conditions have created barriers to a fluid relationship between science and diplomacy, fundamentally characterized by inefficient communication between scientists and policymakers, weak collaboration channels, and duplicated roles, which altogether perpetuate siloed mentalities and a lack of trust between the two communities. Over the last decade, a first influential wave of Latin American scientists, diplomats, and other professionals, including five of the co-authors, have undertaken science diplomacy training provided by specialized organizations. Through these experiences, we recognized the need to elevate awareness and build capacities in science diplomacy in our respective countries and overall, across Latin America. Here, we describe emerging efforts and mechanisms to bridge the gap between scientists and policymakers at the national and regional level. Furthermore, we offer recommendations to amplify the impact of those pioneering initiatives toward consolidating a robust science diplomacy practice across the region. The national experiences described from Costa Rica, Mexico,

and Panama can serve as a roadmap for other Latin American nations in the early process of developing a science diplomacy strategy, so they can also align themselves to a collective pathway. Most critically, we propose a way forward so that Latin America can leapfrog beyond disjointed training of individuals into integrated institutional strategies that can harness the tools of science diplomacy to enhance science-informed multilateral cooperation and enable more effective science-informed policymaking.

Keywords: Latin America, science diplomacy, science-technology-innovation policy, science-based, evidence-based decisions, sustainable development goals, agenda 2030 for development

INTRODUCTION

Although science and diplomacy have been intertwined throughout modern history, the term was only coined in the early twenty-first century (Lord and Turekian, 2007). Science diplomacy is considered an umbrella term describing a wide range of policies and practices at the intersection of science and international affairs to advance national, regional, and global interests (Royal Society, 2010). Among the manifold objectives of nations engaging in science diplomacy are attracting scientific talent from abroad, strengthening national research, and innovation systems, promoting a "country brand" on the global stage, providing avenues for the participation of scientists in the formulation of public policies and coordinating integrated solutions to regional problems.

While Latin America has a long tradition of bilateral and regional cooperation on many topics and issues, science still plays a marginal role in foreign policy and regional integration. With few exceptions, Latin American nations have a relatively immature science, technology, and innovation (STI) ecosystem (IDB, 2010), compounded by some of the lowest public and private investments in STI (Tomilova and Dashi, 2019), all coexisting with profound socio-economic inequalities and large vulnerable populations (UNDP, 2019).

Such challenging conditions, along with deep ideological fractures, have created complex barriers to connecting scientific and diplomatic structures (Gual Soler, 2014) to collectively respond to transboundary emergencies, such as climate change or the ongoing COVID-19 pandemic[1]. Furthermore, most of the intellectual foundations and practical applications of science diplomacy have emerged in the Global North, resulting in a lack of resources in Spanish and contextualized examples to the Latin American region.

Recognizing the immense potential and urgency to develop endogenous science diplomacy capacities in the region, a generation of young Latin American leaders, including five of the co-authors, have sought training at various science diplomacy programs and workshops around the world. Among the most recognized initiatives are those led by the American Association for the Advancement of Science (AAAS, based in Washington, DC), The World Academy of Sciences (TWAS, in Trieste), the European S4D4C project, the SciTech DiploHub (in Barcelona), the International Network for Government Science Advice (INGSA, based in Auckland), and the Innovation and Science Diplomacy School (InnSciDSP in São Paulo) (Mauduit and Gual Soler, 2020). Latin American participants represent a minority in these trainings: at the TWAS courses offered between 2015 and 2020, only 15% of partakers came from Latin American or Caribbean countries (Gual Soler et al., 2020). The InnSciDSP program recruits 50% of its participants from Brazil and the other 50% from abroad, a step in the right direction toward building relevant capacity in the region (Anunciato et al., 2020). Yet despite growing interest, participation in these trainings is still mainly driven by individual or institutional motivation, disconnected from cohesive, larger-scale national strategies.

Five of the co-authors of this article, originally from Costa Rica (MG, ECA), Mexico (AH, LM), and Panama (SLV) met at the 2017 edition of the Science Diplomacy and Leadership Workshop of the AAAS Center for Science Diplomacy, organized by MGS, then Senior Project Director at the AAAS Center for Science Diplomacy[2]. The program, a weeklong immersion in the science diplomacy ecosystem of Washington DC, included expert lectures, institutional visits to U.S. agencies like the Department of State and NASA, foreign embassies, and international organizations. It also trains participants in negotiation skills, cross-cultural communication, and policy understanding. As experts in a variety of scientific disciplines, including chemistry, oceanography, nutrition, virology, and cell biology, we were motivated to bring our scientific expertise to bear in policymaking for the sustainable development of our region.

Upon our return from the program, we engaged with key science and policy stakeholders in our respective countries to help build and strengthen their science diplomacy ecosystems. Here, we present the journey of our countries—Costa Rica, Mexico, and Panama—in science diplomacy and document some of the advances and transformations we have contributed to and their impacts to date. Based on our experiences, we conclude

[1]For example, only a handful of countries in Latin American have the expertise, facilities, and resources to routinely sequence circulating SARS-CoV-2 viruses in order to detect emerging variants, which is crucial for a swift and effective public health response. The lack of capacity for genomic surveillance can result in new variants spreading undetected across borders and jeopardize the health security of the entire region.

[2]Science Diplomacy and Leadership Workshop 2017/American Association for the Advancement of Science.

by proposing suggestions for scaling capacities in science diplomacy across Latin America and provide recommendations to better integrate these pioneering initiatives into the sustainable development strategies of individual countries and the region as a whole.

THREE NATIONAL JOURNEYS IN SCIENCE DIPLOMACY: COSTA RICA, MEXICO, AND PANAMA

Costa Rica

In Costa Rica, close collaborations between the scientific and diplomatic spheres have been ongoing for decades. As one of the first countries to demilitarize, Costa Rica prioritized resources for education, culture, healthcare, and environmental conservation, championing diplomacy, and peaceful engagement over hard power. Back in 1997 Costa Rica (together with Malaysia) proposed a model Nuclear Weapons Convention, in 2013 chaired the first Open-Ended Working Group on nuclear disarmament and eventually marshalled the Treaty on the Prohibition of Nuclear Weapons (TPNW) negotiation conference, which was adopted in 2017 (Umaña, 2018). Not surprisingly a Costa Rican diplomat, Christiana Figueres, led the negotiations efforts at the UN Framework Convention on Climate Change (UNFCCC) toward the Paris Agreement (Figueres, 2020).

Nevertheless, all these efforts only began to be labeled and recognized as "science diplomacy" after 2014, with the appointment of a scientist (Dr. Román Macaya) as Costa Rican Ambassador to the United States. In this role (a first for a scientist to be named ambassador), Dr. Macaya implemented an unprecedented agenda of scientific cooperation between the two countries, resulting in highly impactful collaborations in water, public health, disaster prevention, and remote sensing. In 2015, one such collaborative project linked researchers from the United States Geological Survey (USGS) with the Ministry of Environment and Energy (MINAE), leading to the production of high-resolution, country-scale remote-sensing mapping of underground aquifers (Belcher et al., 2019). This knowledge enables Costa Rica to create evidence-based policies for the use and management of its groundwater resources, which are vital to economically crucial activities such as agriculture and tourism and are especially stressed under a changing climate (Cuadrado-Quesada et al., 2018).

In 2017 another memorandum of understanding (MOU) signed between the University in Costa Rica (UCR), the Costa Rican Social Security (CCSS), and George Mason University, originally designed to produce collaborations on infectious diseases such as zika and dengue, facilitated joint work in the formulation and testing of potential Covid-19 treatments during the 2020 pandemic[3]. This example highlights how international scientific partnerships, when sustained over time, can become advantageous in unexpected ways, most critically during crises.

Other science diplomacy efforts have leveraged strengths in local scientific production to shape diplomatic agendas. For example, research results from the Clodomiro Picado Institute were used as a basis for a 2016 proposal before the World Health Assembly, in pursuit of integrated global action to reduce deaths and disability caused by snake bites. This diplomatic initiative culminated in the 2017 declaration of snakebite poisoning as a priority neglected tropical disease by the World Health Organization (WHO) (Gutiérrez et al., 2017).

In order to formalize these interactions, which so far have been largely *ad-hoc* and serendipitous, in 2019 the Ministry of Foreign Affairs, through its Manuel María de Peralta Foreign Service Institute and the National Academy of Sciences of Costa Rica (ANC), began institutional efforts to link diplomats with researchers through regular convenings. Among the strengths in domestic scientific capacity, that could be leveraged to address relevant regional issues are the prevention of natural disasters through collaboration with the Volcanological and Seismological Observatory (OVSICORI), the conservation of marine biodiversity through the Center for Research in Marine Sciences and Limnology (CIMAR), and biotechnological development through the National Center for Biotechnological Innovations (CENIBiot). At the bilateral level, a recent example of transboundary science-based collaboration between foreign ministries is the joint submission of Costa Rica and Ecuador, requesting to extend their maritime boundaries over the continental shelf between the oceanic islands of Cocos (Costa Rica) and the Galapagos (Ecuador), with the added goal of jointly protecting pelagic species along the migratory passageway, which are threatened by illegal fishing in the area[4].

More recently, with heightened public awareness about the urgency to integrate science into foreign decision making, prompted by the Covid-19 pandemic, a series of virtual webinars were focused on science diplomacy. Last August, the UNESCO office in San José convened the first ever high-level panel in Costa Rica dedicated to the topic, featuring top representatives from the Ministry of Science and Technology (MICITT), the Ministry of Foreign Affairs, and other public entities. A more informal platform called Halo Sessions, geared toward informing the general public, also organized a webinar on science diplomacy in June 2020. Both of the Costa Rican co-authors (MG and ECA) participated in these events. And in early 2021, co-author MGS was invited by the Ministry of Foreign Affairs to present the results of her UNESCO report on science diplomacy in Latin America and the Caribbean to Costa Rican diplomats and invited scientists.

Slowly, these incremental efforts are permeating into the institutional structures. However, many barriers still remain for early-career scientists to follow in Dr. Macaya's footsteps: just like in most countries STEM graduates are not traditionally exposed to science diplomacy curricula nor are there frequent

[3]Mason's NCBID and University of Costa Rica Develop Equine Antibody-based Therapeutic to Neutralize Coronavirus/GMU College of Science.

[4]https://www.un.org/Depts/los/clcs_new/submissions_files/submission_criecu_86_2020.htm

spaces of interaction with diplomats. On the other hand, the Ministry of Foreign Affairs is currently developing a science diplomacy strategy, which would be formalized into the Process of Economic Diplomacy. Furthermore, they are actively seeking cooperation opportunities with science diplomacy e-training platforms that could provide courses on this topic to their personnel.

Panama

Panama has a young science, technology, and innovation system, even if science and technical advances have been crucial since its early national development. Historical scientific institutions, such as the Smithsonian Tropical Research Institute (STRI) and the Gorgas Memorial Institute[5] focused on tropical medicine (Wright, 1970; Adames, 2003), were created at the beginning of the twentieth century to control epidemics during the construction of the Panama Canal. Initially these institutions were administered by the United States, but thanks to close collaboration with local authorities and universities, they have played a central role in advancing Panama's scientific output in public health, biodiversity conservation, and in the training of Panamanian scientists (Sholts et al., 2021). Many new viruses discovered in Panama were first described at the Gorgas, and the results of oceanographic research on underwater acoustics conducted by STRI led the International Maritime Organization (IMO) to modify ship routes and speed limits entering the Panama Canal, with the goal of reducing the risk of humpback whale vessel collisions (Guzman et al., 2020). The BioMuseo, a biodiversity museum, has become a popular tourist attraction with an important role in the education of the general population. However, it was not until the early twenty-first century that these science diplomacy initiatives began to be recognized as such.

In 2017, the National Secretariat for Science, Technology, and Innovation (SENACYT), the science funding agency responsible for developing and strengthening the country's research and innovation systems, selected two young scientists from Panama (co-author SLV was one of them) to participate in the AAAS Science Diplomacy and Leadership Workshop. During our time in Washington DC, we met with a representative of the Panamanian Embassy and the discussion revealed the lack of communication between the diplomatic and the scientific spheres in Panama. It also manifested that most governmental institutions in Panama did not know much about the small but rapidly growing scientific community in the country, nor the breadth of domestic expertise in different scientific fields. Upon our return to Panama, we began conversations to raise awareness about science diplomacy among different stakeholders and institutions. SENACYT and the Ministry of Foreign Affairs (MOFA) approached the scientific community and international partners, including AAAS, UNESCO, and the Inter-American Institute for Global Change Research (IAI), to organize the first science diplomacy workshop in the country as a side event of the Latin American Open Science Forum (CILAC 2018), with the objective of raising awareness among scientists, diplomats, decision-makers, and journalists about the benefits and potential of science diplomacy to support the science system in Panama as well as the role of science to help meet the UN Sustainable Development Goals. Other Panamanian diplomats and scientists, many belonging to the Panamanian Association of the Advancement of Science (APANAC)[6] and to the #CienciaEnPanama movement[7], which seeks to augment science communication and science-informed policy making, continued their international training at the SciTechDiploHub course in Barcelona and the European S4D4C project virtual training, both with the participation of MGS as speaker and/or facilitator.

In 2018 Panama became the first Latin American country to launch an official national strategy for science diplomacy, championed by former Vice President and Foreign Minister Isabel de Saint Malo, in coordination with SENACYT. The strategy establishes that the new diplomatic cadres must be familiar with science, technology, and innovation, and new institutional capacities must be created within Panama's foreign policy structures to align national and international policies with the 2030 Agenda. The action plan included the establishment of a Science Diplomacy Committee to foster dialogue and collaboration between the government and the scientific community. One of the key elements of the strategy was to incentivize the recruitment of STEM professionals to diplomatic careers, so Parliament updated the rules regarding the requirements for entry into the foreign service to open it to graduates from any background (Decreto Ley 60, 2015). The Diplomatic Academy incorporated a module dedicated to science diplomacy, with the participation of several scientists trained in the AAAS, S4D4C, and SciTechDiploHub programs as facilitators. After the launch of the strategy, the institutionalization of science diplomacy is progress, and it is expected to be included in the new Science Law to be approved during 2021. An important takeaway from the Panama experience is that science diplomacy is being used as a model for deploying science advice mechanisms at the domestic level. The MOFA is setting the example for other government institutions on the need to take scientific knowledge into consideration to solve many complex national and regional issues in health, agriculture, environment, and more. Panama is thus an example of how the successful combination of high-level and bottom-up leadership can help position a small country at the forefront of science diplomacy in the region.

Mexico

Over the past 30 years, Mexico has taken important steps toward strengthening institutional capacities to connect science and policymaking, both through science advice and science diplomacy. In 1989, the Federal Government created the first Science Advisory Council (Consejo Consultivo de

[5]http://www.gorgas.gob.pa/historia/

[6]http://www.apanac.org.pa/

[7]https://www.cienciaenpanama.org/

Ciencias or CCC)[8], aimed at providing scientific advice and technical support to the Office of the President. The CCC is composed of distinguished researchers awarded with the National Science and Arts Prize, who participate on an honorary basis and rely on the technical and operational support of an Executive Secretariat to coordinate and communicate with the Federal Government. In 2009, the Center for Research and Advanced Studies of the National Polytechnic Institute of Mexico, supported by several members of the CCC, created a transdisciplinary Ph.D. program to train researchers to analyze the interface between science and technology to address pressing social needs[9]. At this time, the program started to prepare young researchers for opportunities they had not yet envisioned.

As the governance requirements of the science, technology, and innovation ecosystem grew, there was a need to create a dedicated office within the Mexican Government that would link the scientific community with policymakers more effectively. In 2013, the Science, Technology, and Innovation (STI) Office was established within the Office of the Presidency, elevating science advice to the highest political level.

At this point, there was enough momentum within the scientific and policy communities, and opportunities to work between these two worlds started to materialize. Between 2012 and 2018, a new wave of young scientists interested in policy and diplomacy began to emerge, including co-authors AH and LM. We too participated in the 2017 AAAS Science Diplomacy and Leadership Workshop in Washington DC, where we connected with other scientists and diplomats from around the globe and joined a powerful network of collaboration and support. Back in Mexico, we started building bridges between our national research institutions and the international community, by fostering collaboration between the CCC, the President's STI Office, the National Council of Science and Technology (CONACYT), and international organizations such as AAAS[10], the International Network for Government Science Advice (INGSA), the Foreign Ministries Science and Technology Advice Network (FMSTAN)[11], and the European Science Diplomacy Cluster.

In 2017, the STI Office, the CCC, and the AAAS Center for Science Diplomacy co-organized the *1st Mexican Congress on Science-Informed Policy: Enhancing the Science-Policy Interface*[12] with the overarching goal of bringing together the science and policy communities in Mexico and the Americas[13]. The program was intended to provide diverse perspectives on the existing mechanisms and models that different countries were deploying to strengthen the science-policy interface. A concrete outcome of the event was a collaboration between CCC, AAAS, and the Diplomatic Academy of the Ministry of Foreign Affairs (Instituto Matías Romero) to develop an online course on science diplomacy and the opportunities and challenges of the Fourth Industrial Revolution for the members of the Mexican Foreign Service and officials of the Foreign Ministry. The course, developed by LM and MGS, was the first to be introduced at the Diplomatic Academy on this topic, and now has become part of the educational curriculum of Mexican diplomats.

The efforts to strengthen science-policy interfaces in Mexico were not limited to the Executive Branch. In the Federal Legislative Branch, an Office of Scientific and Technological Information for the Congress of the Union (INCYTU) was established and operated by the Scientific and Technological Consulting Forum (FCCyT) between 2016 and 2018. However, as it was external to Congress and financially dependent on the Executive, it had a modest impact and disappeared early 2019. In 2021, a new proposal has been passed to create an internal Office for Science Advice in the Chamber of the Deputies, which will depend on the Congress both financially and structurally. Additionally, the Federal Law of Science and Technology will be updated as a consequence of a Constitutional amendment. The objective of this law must include mechanisms for strengthening the institutional frameworks for the long-term development of science and technology, to consolidate the role of advisory bodies and research organizations such as the CCC, and to recommend the creation of new structures dedicated to science diplomacy and science advice not only in the executive and legislative branches, but in other levels of governance. An example at the sub-national level is a science policy fellowship program hosted by the Government of Mexico City (CDMX), led by AH and inspired in the AAAS Science Technology and Policy Fellowship (STPF), to place Ph.D. scientists in government offices for 1 year to develop knowledge and skills to navigate the science and public policy nexus[14]. The program is supported by AAAS (USA), FECYT (Spain), IIASA (Austria), and the United Kingdom, who helped deliver orientation training to help fellows prepare for their placement and identify and develop their transferable skills. The first cohort of the program—the first of its kind in Latin America—has placed fellows in the Health, Environment, Economic Development, and Mobility Ministries in CDMX and will be expanded to other ministries in the coming years.

THE WAY FORWARD: FROM EMERGING INITIATIVES TO INTEGRATED STRATEGIES

The COVID-19 pandemic response has manifested the divide between science, policy and society in many countries, and Latin America is no exception. Despite the promising advances presented here, our countries are still reactive, rather than anticipatory, to the challenges that require robust scientific input and regional and global cooperation. Governments must adopt this new vision of development and prosperity based on strengthening their science, technology, and

[8]http://www.ccciencias.mx/en

[9]https://www.transdisciplinario.cinvestav.mx/english-profile

[10]Diplomacia científica en América del Norte: México, Estados Unidos y Canadá.

[11]Reunión de Red de Asesoría Científica y Tecnológica para Ministerios de Relaciones Exteriores (FMSTAN).

[12]https://www.aaas.org/news/aaas-and-mexican-scientific-council-sign-collaboration-agreement

[13]https://www.ccciencias.mx/es/asesorias/item/443-mexican-congress.html

[14]https://sectei.cdmx.gob.mx/comunicacion/nota/presentan-programa-de-estancias-de-asesoramiento-gubernamental-pionero-en-america-latina

innovation systems, and connecting knowledge to policy and society. Much more needs to be done to foster local and international cooperation to strengthen communication channels between scientists, diplomats, and policy makers. We show how the leadership of young pioneers, the co-authors being only few examples, supported by and trained in international programs have been a crucial first step to create a group of champions of science diplomacy in the region.

First, national and regional institutions should take the lead in establishing regular capacity development in science diplomacy for scientists and diplomats, from junior to senior, rather than relying on external training opportunities in places like the United States or Europe. For science diplomacy to have a lasting impact in the development of the region, in resolving societal, environmental and health issues, it needs to go beyond one-off workshops, seminars, and conferences. Capacity development goes far beyond training[15]: it recognizes the complexity of processes which it aims to influence and the need for multiple knowledges (topical, political, societal, traditional, etc.), provides practical and immersion opportunities to help bridge the gap between theory and practice, and requires a large component of support and follow-up to foster the emergence of vibrant and self-sufficient networks. This can be achieved with the creation of specialized structures within executive and legislative branches, as well as in diplomatic missions, including the deployment of science counselors and attaches to connect the local scientific community with ecosystems of innovation abroad- as well as the diaspora. Science policy fellowship programs, internships, and pairing schemes connecting scientists with legislators and civil servants. Universities to start changing mindsets and cultures that the default career path for a scientist is academia.

One national capacities are established, the next step will be the creation of a regional network of institutions dedicated to building science-policy interfaces, to collectively identify and tackle shared problems in the Latin American region. A pioneer effort in this direction is the Inter-American Institute for Global Change Research (IAI)'s Science, Technology, Policy (STeP) Fellowship Program[16], an innovative pilot program to enhance human and institutional capacities in IAI member countries, such as Mexico, Argentina, United States, and Canada. The STeP program is training future Latin American and Caribbean leaders to participate in the science-policy interface through hands-on learning supported by professional development and mentorship (the science policy and science diplomacy tracks of the STeP training are delivered by AH and MGS, respectively). Multilateral organizations and regional bodies, such as UNESCO, CELAC, IAI, etc., must coordinate a regional science diplomacy agenda, maximizing connections provided by existing intergovernmental bodies and agreements, and avoiding redundancies and fragmentation. As young scientists are a crucial part of this strategy, early career research networks, associations, and academies, like the Global Young Academy, TWAS Young Affiliates and national academies should also participate in this effort[17].

We must caution, however, against a too idealized vision of science diplomacy and recognize its limits and even potential negative consequences. Over the last 5 years, nations retreating from multilateralism, trust in science and expertise in decline, and increasing technological competition between major powers has challenged the "romantic view" that has dominated the mainstream discourse on science diplomacy (Rungius and Flink, 2020), prompting intense academic scrutiny of its theoretical and practical frameworks and narratives. Criticism includes neglecting colonialist and imperialist roots of historical scientific cooperation episodes driven by the Global North, such as the Smithsonian Institution, now being reframed as examples of science diplomacy, and discomfort with the idea of science diplomacy because of concerns of compromising academic freedom and scientists being instrumentalized for political purposes (Gual Soler, 2020). As we have seen with the Covid-19 pandemic, science cannot substitute politics, and scientists should not take the role of elected officials. Science and evidence are not the only factors to consider in decision-making, and policymakers must constantly balance competing interests from all sectors of society. It is our responsibility, as science advisors and science diplomats, to provide evidence-informed options to the policy process at the domestic and international levels (Maani and Galea, 2021). To achieve this, we need adequate institutional infrastructures, boundary-spanning professionals and academic incentives to bring science and diplomacy into closer orbits and promote trust-building between their communities, so that they can join forces toward achieving the Sustainable Development Goals for the well-being throughout Latin America and the world.

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[15]https://www.diplomacy.edu/blog/what-difference-between-training-and-capacity-development

[16]http://www.iai.int/en/step

[17]https://www.sciencediplomacy.org/editorial/2021/twelve-months-covid-19-shaping-next-era-science-diplomacy

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OPINION
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Science Diplomacy as an Umbrella Term for Science Advisory in Public and Foreign Relations in Small Developing Countries: The Case of Panama

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INTRODUCTION

The history of Panama has been influenced by science and technology since its inception. The geological event that formed the isthmus that united North and South America, more than 3 million years ago, gave it its strategic location and one of the greatest biodiversity riches in the world (O'Dea et al., 2016). The construction of the Panama Canal was one of the most ambitious engineering works of its time, but the poor management of workers' health conditions played a key role in the failure of the original project, led by the French (Marshall, 1913). When the United States took over the work, right after Panama's independence from Colombia in 1903, Dr. William Gorgas implemented measures similar to those taken in Cuba following Dr. Carlos Finley's research to clear yellow fever mosquitoes (Mason, 1916; Chaves-Carballo, 2005). This allowed the successful completion of a great work of engineering, becoming one of the first examples of Science Diplomacy (SD) for global health.

Despite the complex diplomatic relationship between the US and Panama, both countries agreed to establish in Panama some of the best institutes in Tropical Ecology and Medicine, like the Smithsonian Tropical Research Institute (STRI) and the Gorgas Memorial Institute (GMI). Implemented by the US but officially administered by the Panamanian Government since 1990, the latter has become an international reference institute for tropical and public health research (Wright, 1970; Adames, 2003). STRI continues to be an American institute that studies all aspects of the abundant and untapped biodiversity in the country (STRI, 2018).

Many of the most relevant historical scientific and technological events in Panama are intertwined with political decisions and have occurred generally under the leadership of another country, or were undertaken by an interested group of scientists and technicians and not as a national strategy. It was not until the end of the 20th century, that Panama began to systematically develop and strengthen its scientific ecosystem with the creation of the National Secretariat of Science, Technology and Innovation (SENACYT) (Romero and Quental, 2013). Currently, it is the main public institution funding research and the first to promote the

importance of training young scientists in communication, relational and leadership skills in SD (Gittens and Lopez-Verges, 2018). SENACYT also encourages the interaction between the scientific community and the Ministry of Foreign affairs, as well as researchers' involvement in different national strategies and projects.

PANAMA'S SCIENTIFIC DEVELOPMENT IN ITS HISTORICAL CONTEXT AS A BRIDGE FOR SCIENCE DIPLOMACY

The concept of Panama as a nation is closely linked to diplomatic relations and, although not called as such at the time, SD. First, to achieve the construction of major engineering works, such as the Transisthmian Railway or the interoceanic route, which helped with the desired political separation from Colombia. And once independent, to gain sovereignty in the governance of its territory without intervention from the United States in the Canal Zone, after decades of social unrest due to their presence that led to the loss of Panamanian lives and severed diplomatic relations. This, undoubtedly, has marked how Panama has built its scientific and technological development and international collaborations.

The strategic geographical position of the isthmus has allowed communication and people exchange from all over the world. This, together with Panama's great biodiversity, has laid the foundations of the scientific institutions that the country has nowadays. The presence of STRI in Panama exemplifies this. During the construction of the Canal, American engineers built a dam on the Chagres River, near the Caribbean coast, to create Gatun Lake and facilitate the passing of ships. The largest human-made lake in the world, at the time, allowed the study of the rainforest biodiversity in newly created islands, like Barro Colorado, and attracted scientists from all around the world (STRI, 2018). STRI is a unique example of a cutting-edge scientific research institute based in the tropics. The collaboration between Panama and the United States, which has lasted more than a century, has been key. STRI is an institution that contributes to global knowledge, something of great relevance in these moments of crisis due to climate change (STRI, 2018).

GMI constitutes another relevant historical case. In 1921, Panama's President Belisario Porras created it, as a tribute to Dr. William C. Gorgas. In 1928, the institute was inaugurated in Panama City and was administered by the US until 1990. GMI is devoted to research on tropical medicine. Its main focus includes parasitic diseases such as malaria, toxoplasmosis, leishmaniasis and Chagas disease, as well as diseases produced by arboviruses, retroviruses, papillomaviruses and respiratory viruses, among others (Wright, 1970; Sanchez, 1974). Its scientific activity has produced over 1139 publications (ICGES, 2021).

Panama, as a Republic, has had a close, and at certain points complex, diplomatic collaboration with the United States and neighboring countries. This has fostered the exchange of knowledge, technology and trained human resources, which have derived in the basis of our SD, established as a strategy a few years ago.

STRATEGIES TO ESTABLISH THE PILLARS OF SCIENCE DIPLOMACY IN PANAMA

In 2018, on the occasion of the Day of the Panamanian Diplomat, the Government, through the Ministry of Foreign Affairs (MOFA), launched the "National Strategy for Science, Technology and Innovation (STI) Diplomacy", as an instrument for the 21st Century diplomacy (SENACYT, 2018; SENACYT and MIRE, 2019). This effort, led by SENACYT and MOFA, allowed Panama to become the first Latin American country with a national strategy on SD.

According to the Vice-President and Minister of Foreign Affairs at the time, Isabel de Saint Malo de Alvarado, the combination of science and diplomacy is accountable for relevant milestones. For instance, the agreement between the United States and the Organization for the Prohibition of Chemical Weapons to destroy the old chemical munitions, left in San Jose Island by the United States military (Pugliese, 2002; AFP, 2019) or the approval of new navigation routes in Panamanian waters to minimize collisions between ships and migrant humpback whales by the International Maritime Organization (Guzman et al., 2013; Cogley, 2014).

The current Government Administration of President Laurentino Cortizo, in charge since July 2019, has created for the first time a Science Cabinet that includes participation from all relevant ministries and is under the coordination of SENACYT. It has established a Technical-Legal Committee, comprising representatives of the different public and research institutions, that is currently working on a draft law to update the legal framework for SENACYT and the National STI System. One of the chapters relates to the concept of SD as an umbrella term for science advisory.

MOFA, together with SENACYT, is working on this action plan aimed to bridge the gap between key stakeholders to promote strategic investment in major projects that will benefit the Panamanian population. Namely:

- The establishment of a pharmaceutical hub in Panama.
- Initiatives for the conservation, restoration and use of invaluable biodiversity, threatened by climate change, to protect Panamanian communities that face rising sea levels and more extreme weather events.
- Biotechnological startups able to implement a new bioeconomy and the need to guarantee Panama's water and food security through a vigorous and competitive agro-industrial sector.
- Biomedical innovations to improve citizens' quality of life against the rising incidence of infectious and chronic diseases in the population, aggravated by aging.
- Research platforms for the generation of knowledge as a tool to improve education quality in Panama.

DISCUSSION

The concept of SD, almost unknown five years ago by both scientists and diplomats in Panama, has gone through a broad inter-institutional and inter-sectoral discussion during the establishment of the national strategy for SD. On the one hand, this exercise brought together the scientific and technological ecosystem main actors to define a unified vision of the priorities and strengths in STI for the country, so that Panamanian diplomats could better promote national interests. On the other hand, it made the scientific community visible to diplomats and foreign policymakers, but also to most governmental institutions and civil society that could benefit from the local generation of knowledge. These interactions between scientists, public institutions and civil society have helped to create strong and lasting relationships that are leading to science advisory opportunities for evidence-based public policy (CCIAP, 2019; Redaccion, 2020).

Partially because of its relatively young scientific community, the concept of SD was discussed and implemented before the country had any real science advisory legal framework to use scientific knowledge to inform decision-makers. For this reason, the term "Science Diplomacy" has become a synonym for "Science Advice". Therefore, the Technical-Legal Committee of the Science Cabinet is considering introducing a chapter in the new law for the National STI System that will combine both terms. A small country such as Panama has traditionally imported technology and even science expertise in the form of foreign scientific consultants for public policymaking or business decision-making. The goal is that this new legal framework will provide diplomats and decision-makers with more access to local scientific expertise.

By using the soft power of science in policy advice, the growing community of science diplomats can boost Panama's development and take part in different issues at national, regional or global scale. The implementation of SD in Panama offers a ray of light to banish the infamous expression "no one is a prophet in their own land" suffered by many countries in the region. There is a long way to go, but if Panama manages to follow the path set up by its national strategies, it will demonstrate that small middle-income countries can be key players in designing a new multilateral partnership for sustainable and equitable development.

AUTHOR CONTRIBUTIONS

All authors, TC, MP-S, SL-V, JP, AV, RG, and IT-A participated in the discussion and the writing of the opinion statement. MP-S, SL-V, RG, and IT-A participated in the final editing of the text.

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Ocean Science Diplomacy can Be a Game Changer to Promote the Access to Marine Technology in Latin America and the Caribbean

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Ocean science is central in providing evidence for the implementation of the United Nations Law of the Sea Convention. The Convention's provisions on transfer of marine technology to developing countries aim at strengthening scientific capabilities to promote equitable opportunities for these countries to exercise rights and obligations in managing the marine environment. Decades after the adoption of the Convention, these provisions are under implemented, despite the efforts of international organizations, such as IOC-UNESCO. Latin America and the Caribbean struggle to conduct marine scientific research and seize the opportunities of blue economy due to the limited access to state-of-the-art technology. Ocean science communities in these countries are subject to constraints not foreseeing in international treaties, such as unstable exchange rates, taxation, fees for transportation, costs of maintenance and calibration of technology, challenges to comply with technical standards, and intellectual property rights. Action is needed to overcome these challenges by promoting a closer tie between science and diplomacy. We discuss that this interplay between science and international relations, as we frame science diplomacy, can inform on how to progress in allowing countries in this region to develop relevant research and implement the Convention. We provide concrete examples of this transfer of marine technology and ways forward, in particular in the context of the UN Decade of Ocean Science for Sustainable Development (2021–2030).

Keywords: science diplomacy, access to technology, Latin America, caribbean, UN decade of ocean science

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INTRODUCTION

For the past decades, as the same time as scientific discoveries allowed us to acknowledge the critical importance of the ocean to our livelihood, it was also significant to demonstrate the serious consequences of anthropogenic impacts on the marine environment threatening this life-supporting system (Rockström et al., 2009). It is a humanitarian solicitude to preserve and sustainably use the ocean, conserving its essential ecosystem services for generations to come (Griggs et al., 2013). However, science and technology have not served all countries equally (Harden-Davies and Snelgrove, 2020; Ocampo and Vos, 2008, pp. 34–36). As the UN Decade of Ocean Science for Sustainable Development makes its debut, this paper seeks to assist it by discussing current limitations hampering countries in Latin America and the Caribbean from

accessing and using marine technologies to develop the science needed to inform decisions and international negotiation processes in an equitable basis.

Science has been responsible for both acknowledging the critical importance of the ocean as well as identifying its multiple stressors and delicate ecological limits (Nash et al., 2017). With the increasing significance of environmental and ocean related discussions in international fora, scientists are called to provide evidence on life-threatening issues, such as natural and human induced hazards or food security and pollution. More recently, science has been pushed in the ocean international arena to assume a more relevant social role rather than just unveiling the unknowns (Wisz et al., 2020). Scientists are requested to provide empirical inputs to global decision-making processes, with the potential to build international partnerships to overcome these collective humanitarian challenges (Fedoroff, 2009). Ocean scientists are also being urged to deliver social goods and foster capacity development and transfer of marine technology (IOC-UNESCO, 2020b)[1]. Nevertheless, ocean knowledge production depends upon the access and application of available marine technologies. These include not just research vessels, underwater vehicles and oceanic instruments, but all sort of expertise and knowledge-based materials, including databases and information, as formatted by the Intergovernmental Oceanographic Commission (IOC) of UNESCO (IOC-UNESCO, 2005). Therefore, accessing marine technologies is critical to develop ocean research that can ultimately provide evidence to decision-making.

Developing countries struggle to develop or access marine technologies in spite of some attempts to address this issue (Alexander et al., 2020). Vast ocean areas are still unmapped and unknown to humanity, in particular the Southern parts of the Atlantic and of the Pacific, mostly due to the lack of access to marine technologies and incipient human capacities of countries in these regions (Inniss et al., 2017; IOC-UNESCO, 2017). The asymmetrical distribution of scientific knowledge and technologies not only impinge discoveries, but also reduce possibilities of developing countries to table their needs in international negotiations on ocean affairs based in sound evidence. As one of the major historical battlefields between developing and developed countries, the United Nations Convention on the Law of the Sea (LOSC) enshrines provisions to promote international cooperation on marine scientific research (MSR) and the transfer of marine technology (TMT)[2] (Anand, 1982; Soons, 1982; Nordquist et al., 1990; Gorina-Ysern, 2004). However, these provisions are among the less implemented in the LOSC (Long, 2007; Long and Chaves, 2015; Salpin et al., 2018).

Enforcing the LOSC rules on MSR and TMT in an equitable manner has been in the forefront of the international agenda for developing countries, as for instance in the current negotiations of a legally binding implementing agreement to regulate the conservation and sustainable use of marine biodiversity beyond national jurisdiction (BBNJ agreement) (Long and Chaves, 2015; Harden-Davies, 2018). The UN Decade of Ocean Science also lies within this background, focused on balancing countries' capabilities to promote sound science for social and environmental benefit. Nonetheless, it is uncertain how the geopolitical interactions between the actors negotiating these processes will occur, as well as which roles will be played by scientific evidence.

The Decade is a diplomatic movement to foster marine research in search of fulfilling the targets established under the Sustainable Development Goal 14, Life below Water (SDG14), in which ocean science is pivotal (Visbeck, 2018). As a coordination effort to this end, the Decade will need to deal with the transfer of marine technology to the Global South, without which ocean science cannot progress globally as requested. The Decade's ambition to involve other ways of knowing in science making, plus improving this knowledge uptake in society's decision making, will need to involve social scientists further (Ryabinin et al., 2019). Social sciences are called to the front to ask the correct questions and bridge all ways of knowing (Claudet et al., 2019). In this context, science diplomacy will be pivotal for the Decade's success.

International Relations scholarship has overseen the role of science and technology in theorizing the relations of power and influence between countries (Mayer et al., 2014). Globalization, for instance, has been mostly researched in economical contexts, whereas science has been described as an influential soft form of power, attracting partner countries to one's interests and values, rather than using force and coercion (Nye, 2017). Science diplomacy is a recent field of academic research that investigates exactly the relationship between science and international relations, opening a new horizon for scholarship in International Relations (The Royal Society, 2010; Gluckman et al., 2018; Rungius et al., 2018). Although its definition is still disputed [a good debate can be found in Flink (2020) and in Ruffini (2020b)], for the purpose of this piece, science diplomacy is framed as a practice by which international relations support and are supported by scientific research, evidencing sometimes conflicting national, regional, and global interests. The current debate around the topic has provided insightful perspectives to think about fostering the access to marine technology for developing countries (Griset, 2020).

This paper assesses how science diplomacy can be a significant tool for Latin America and Caribbean States to overcome challenges in negotiations related to accessing marine technologies and capacity building at the international level, ultimately enhancing the regions scientific capacities. Profiting from the opportunity presented by the implementation of the UN Decade of Ocean Science for Sustainable Development (2021–2030), we propose recommendations that could leverage the implementation of the legal rights and obligations on transfer of marine technologies reducing global inequalities in the access and use of marine technologies.

[1]For the purpose of this paper, marine technology encompasses the "instruments, equipment, vessels, processes and methodologies required to produce and use knowledge to improve the study and understanding of the nature and resources of the ocean and coastal areas" (IOC-UNESCO, 2005, p. 9)

[2]In the absence of a clear-cut definition of marine scientific research in the United Nations Law of the Sea Convention (LOSC), we understand this activity as "any study or related experimental work designed to increase [hu]man's knowledge of the marine environment" (Soons, 1982)

METHODS

We conducted a legal analysis of the provisions adopted in the LOSC regarding the promotion of MSR and TMT, focusing on the rules with especial provisions for developing countries. Additionally, official documents aiming at implementing such provisions were analyzed, in particular those from the Intergovernmental Oceanographic Commission from UNESCO (Gonçalves, 1984; Harden-Davies and Snelgrove, 2020). Some of the perspectives and examples provided were drawn from the authors' experience in managing scientific programs in the region and through the collection of views from researchers in the field over time. We acknowledge the importance of analyzing how social, cultural and political relations can add layers of complexity in the discussion of implementing the transfer of marine technology obligations, however, this has not been the focus of this paper.

Reasons Why Marine Technology Transfer Is Critical in Latin America and the Caribbean

Globalization is usually themed after economic relations but became a facilitator movement of international scientific cooperation, in particular in issues of global concern, such as ocean health (Held et al., 1999; Carter, 2008). With a more engaged global scientific community, the knowledge produced could reflect a form of scientific consensus that could inform diplomacy. However, the uneven participation of researchers from Latin America and the Caribbean in global ocean assessments show that this consensus might be reflecting views from a narrow group of scientists, lacking inclusivity (IOC-UNESCO, 2020a; Tessnow-von Wysocki and Vadrot, 2020). Thus, globalization has provided good opportunities for the evolution of Science but has still much to progress in terms of accommodating knowledge from other communities, in particular researchers from the Global South (Biermann and Möller, 2019; Kraemer-Mbula et al., 2020).

Researchers from developed countries often access funding and infrastructure to conduct research in Latin America and the Caribbean waters. As principal investigators of such research projects, these researchers usually apply only a small portion of the funding in the foreign field, leaving local contributors with limited access to research equipment. This has been evident in the current Covid-19 pandemic, with Northern scientists regretting having lost their field work access due to travel bans, thus jeopardizing entire research projects (de Vos, 2020). What should be regretted is that those research projects did not provide a well-equipped and trained personnel on the ground. If done so, research would have been preserved, so as capacity development and access to technology provided, a win-win situation.

Ocean scientists in Latin America and the Caribbean struggle in many ways to develop world-class marine research. First, research budget is limited and allocated in local currency, subject to high fluctuating exchange rates. This conversion is necessary to import equipment and other research inputs from foreign companies, usually from developed countries. Research proposals' budget are challenged in predicting this currency fluctuation as well as adding the high costs related to taxation and transportation. As a result, research inputs and equipment can become prohibitive. Managing these discrepancies becomes a fundamental part of doing ocean science in the Global South.

Second, once an equipment is imported, it needs to be calibrated and maintained by certified services so results can be compared, and data defined as accurate. In general, these certified services are only provided by the same companies that manufacture the devices. The contracting party is usually hold accountable to cover the costs of the technician's travel and accommodation, plus the service itself. Establishing local or regional offices in the region would provide not only a solution, but also foster jobs and boost small enterprises and start-ups. Ocean technology companies claim that the market share in Latin America and the Caribbean is insufficient for opening branches in the region. Indeed, limited funding results in less acquisition of equipment, making the market share low for those companies. Countries could develop certified laboratories to provide maintenance and calibration. Brazil, for example, has this capacity established in universities. Those laboratories are however unable to be certified due to the high international standards for accreditation, costly to comply with. Without this certification, one can just loose the equipment's warranty or have the data being trashed out for the lack of quality assurance.

Lastly, the global ocean scientific community moves steadily in determining essential ocean variables, i.e., a minimum requirement of observations to monitor the state of the ocean environment and predict trends which are useful to inform society and policy makers (Lindstrom et al., 2012). It has been acknowledged that complying with such standards will be challenging to the developing world, in particular because of the fragmented ocean international governance framework and the lack of coordination and security in funding schemes (Bax et al., 2018). Capacity development and transfer of marine technology are critical to instrumentalize a coordinated set of data that will allow better forecast and modeling of the marine environment (Miloslavich et al., 2018). Despite some endeavors in the Pacific and Southern Asia (Bax et al., 2018), the overall scenario in ocean observations is still detrimental (Tanhua et al., 2019).

All in all, ocean scientists in the South have limited research budget in local currency with highly fluctuating exchange rates. Much of this budget is then spent in keeping up with international standards, that determine data accuracy, thus allowing replicability and comparison. To make things slightly challenging, the competition for shiptime is intense since there are not many research vessels available. Thus, international cooperation is essential to access and deploy ocean technologies. Governments need to support researchers in negotiating equitable and fair platforms for sharing research infrastructure and co-developing marine technologies.

The Legal Framework That Supports the Transfer of Marine Technology

There is a compelling international legal framework that aims at fostering the transfer of marine technologies, in particular in the context of the United Nations Law of the Sea Convention (LOSC).

The LOSC provides a comprehensive framework regulating the jurisdiction of States Parties and activities taking place at sea, interacting with other instruments, actors and regimes (Trevisanut et al., 2020). Even though scientific evidence is interwoven in many provisions of the Convention, the transfer of marine science and technology is enshrined in part XIII (Marine scientific research), part XIV (Development and transfer of marine technology), and articles 143, and 144. Whereas the link between the framework on marine scientific research, transfer of technology and capacity development has been analyzed elsewhere (Harden-Davies and Snelgrove, 2020), the literature lacks a closer look into the special rules directed to developing countries.

The obligation of transferring marine technology generally covers 1) access to data, information and knowledge; 2) training human resources on science and technology; 3) promoting access to equipment and infrastructure; and 4) promoting international, regional and national scientific and technical cooperation (Harden-Davies and Snelgrove, 2020). In more details, within the framework of scientific cooperation, there is a special obligation for States, alone or in collaboration, to promote the flow of scientific data and information, as well as the transfer of knowledge resulting from MSR and transfer of marine science and technology to developing countries. Additionally, international efforts must focus on increasing the autonomous scientific capability and infrastructure of these countries through capacity development actions as well as the establishment of national and regional research centers aiming at not only increasing skills in pure science, but also to improve the social and economic development of these countries (art. 244 (2), art. 266 (1)(2), art. 268 (d), art. 275, art, 276 LOSC). Aligned with States, International Organizations must endeavor to conclude focused programmes of technical cooperation for transferring all kinds of marine technologies and technical assistance to States that have not been able to establish or promote their own technological capacities in pure or applied marine sciences (art. 269 (a)). Even when not intermediated by international organizations, the TMT between States must consider the needs and interests of developing countries (art. 272, LOSC). Article 267 provides means of interaction with other legal regimes by counterbalancing the obligation to transfer marine technology with the obligation of due regard the rights and duties of holders, suppliers and recipients of marine technology. **Table 1** summarizes the provisions in parts XIII and XIV with rights and obligations for developing countries.

Understanding that technological and scientific developments would require normative adaptation over time, article 271 calls for collaboration though international organizations for enacting criteria and guidelines to facilitate the TMT taking into account the interests and needs of developing countries, including skills and technology regarding activities in the Area, i.e., the seabed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction. Even though no specific organization is mentioned in LOSC, IOC-UNESCO has acted as the focal point for implementing parts XIII and XIV. Other organizations with competences related to ocean sciences are the Food and Agriculture Organization (FAO), the International Seabed Authority (ISA) and the International Maritime Organization (IMO), among others with a more regional focus (Nordquist et al., 1985, pp. 558–560; United Nations, 2010). The conduct of MSR has increasingly been undertaken by cooperative arrangements, what is fostered by articles 424 and 244 of the Convention. Besides, IOC has been leading initiatives of capacity building in marine scientific research and has assumed a pivotal role in discussions in the BBNJ negotiations, which has transfer of technology and capacity building in the core of the negotiations (Harden-Davies, 2016).

In 1994, a new Implementing Agreement under LOSC was negotiated to implement Part XI regarding activities in the Area (United Nations, 1994). Developed countries were dissatisfied with the regime negotiated in LOSC for the Area, including the obligation of mandatory technology transfer. As part of the compromise to acquire the necessary number of ratifications for the LOSC to come into force, the 1994 Agreement modified article 144 introducing new principles in disfavor of developing countries (Galindo, 2006). First, it has linked the conditions to facilitate the access of technology to the terms of the open market or through joint-ventures, reducing favorable prices to developing countries. Second, it has submitted technology acquisition to the effective protection of property rights, one important limitation for TMT in current times, as we shall discuss below (United Nations, 1994). Despite the setbacks introduced by the 1994 Agreement, the ISA has established an Endowment Fund in 2006 to support the participation of scientists from developing countries in research projects (United Nations, 2010), which, in turn, has been subject to some criticism (Jaeckel et al., 2016).

In spite of the comprehensive legal framework favoring scientific cooperation and marine technology transfer with particular provisions focusing on increasing capacities in developing countries, part XIII and part XIV of the LOSC are under-implemented (Long, 2007) As a result, there is currently a lack of balance between developed and developing countries in producing ocean science (IOC-UNESCO, 2017). These concerns are vivid in many international stages, such as in the BBNJ negotiations, where countries of the Global South are requesting more legal opportunities for accessing marine technologies. As the scope of the Decade is broader than the BBNJ, we claim that it could act more ambitiously as a springboard to foster the implementation of the special rules on marine scientific research and transfer of technology for developing countries, particularly considering the rules on international scientific cooperation aforementioned and the positive outcomes to promote transfer of technology of informal arrangements.

Challenges and Opportunities in Implementing the Transfer of Marine Technology

Implementing the LOSC Rules on Transfer of Marine Technology

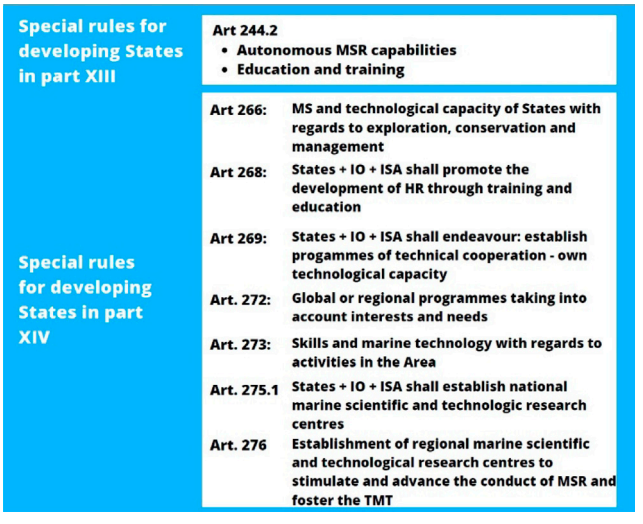
Technology transfer can mean a diversity of processes. For example, it can be applied to a dual use of a certain technology being transferred from one field of application to another. It can also represent the factual physical movement of an asset (or even immaterial elements, such as know-how or technical information) or people or a set of capacities between places. Here, we will address technology transfer as the transfer of systematic knowledge for the manufacture of a product, for the

TABLE 1 | Law of the Sea Convention provisions in part XIII and part XIV (Development and transfer of marine technology) specifically dealing with developing countries.

Special rules for developing States in part XIII	Art 244.2	States and IO shall transfer scientific data, information and knowledge States and IO shall strengthen the autonomous MSR capabilities of developing countries States and IO shall strengthen human resources of developing countries through education and training
Special rules for developing States in part XIV	Art 266	States shall promote the development of MS and technological capacity of States with regards to exploration, conservation and management
	Art 268	States, IO, ISA shall promote the development of HR through training and education
	Art 269	States, IO, ISA shall endeavour: establish progammes of technical cooperation - own technological capacity
	Art 272	IO shall coordinate Global or regional programmes taking into account interests and needs
	Art 273	States, OI and ISA shall facilitate the transfer of Skills and marine technology with regards to activities in the Area
	Art 275.1	States, IO, ISA shall establish national marine scientific and technologic research centres
	Art 276	States, IO and ISA shall promote the Establishment of regional marine scientific and technological research centres to stimulate and advance the conduct of MSR and foster the TMT

HR, Human Resources; IO, Intergovernmental Organizations; ISA, International Seabed Authority; TMT, Transfer of Marine Technology; MSR, Marine Scientific Research; MS, Marine Science.

application of a process or for the rendering of a service and does not extend to the mere sale or lease of goods (United Nations Conference on Trade and Development, 2014).



Marine technology transfer is generally referred to in the context of the IOC Criteria and Guidelines on the Transfer of Marine Technology, or GTMT, as illustrated in Box 1 (IOC-UNESCO, 2005). GTMT details the need for a clearing-house mechanism, by which interested stakeholders could identify technology-holders and technology needs among the global ocean community. This clearing-house mechanism is not yet established, although IOC has created a Group of Experts on Capacity Development that have produced recommendations on ways to move forward, based in other organizations' models (IOC-UNESCO, 2019). IOC has, however, established a proof-of-concept trial clearing house mechanism in its regional body for the Latin America and the Caribbean through a dedicated website.[3] This trial version makes available information on some of the region's institutions, experts and research vessels, but a match making feature for those seeking available marine technologies from the North is inexistent. Therefore, after 15 years of the establishment of those criteria and guidelines, the world has yet to see transformational technology transfers that result in a balance between countries in the access and use of marine technologies (IOC-UNESCO, 2017; Salpin et al., 2018).

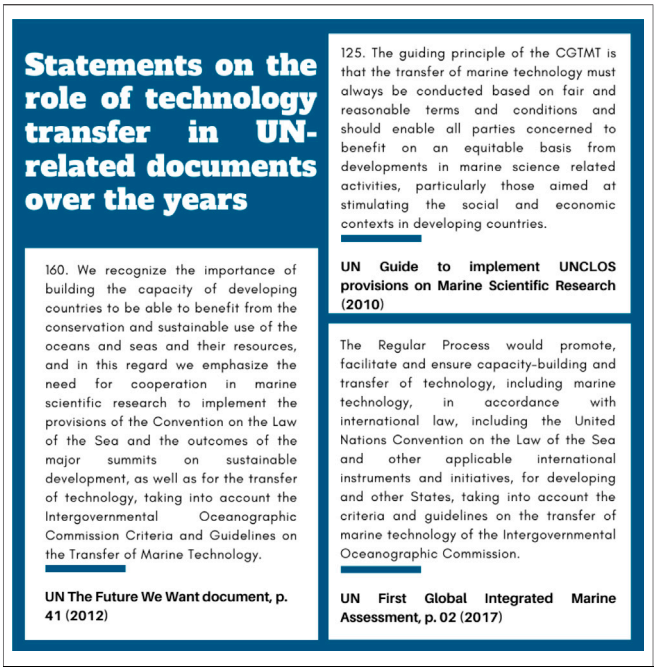
Diplomacy cannot afford to postpone the debate on the effective transfer of marine technologies. As the world's population grows, there will be a race to explore the ocean natural resources further. Thus, ocean sustainable development based on the best available scientific knowledge is of utmost importance for future generations, in particular for developing countries (Hassanali, 2020). Bearing this in mind, the United Nations proclaimed the next decade as the UN Decade of Ocean Science for Sustainable Development (2021–2030).

The Decade of Ocean Science shall be a good opportunity to foster the debate around effective manners to progress in granting opportunities for developing countries to access marine technology and capacity development (Claudet et al., 2019), by implementing the regimes enshrined in part XIII and XIV of the LOSC. For this to happen, the implementation of the Decade should be centered in searching for equality in the access and use of marine technologies for sustainable development and human and environmental wellbeing. Terms such as co-development of technology instead of transfer, with a more equitable and linear participation of stakeholders, should also be promoted. In this sense, science diplomacy can inform on practices applicable to fostering this balance.

Scientists Leading the Transfer of Marine Technology

In practice, marine technology transfer has relied less in formal intergovernmental diplomatic routes and more in peer-to-peer exchange. Peer-to-peer cooperation is a basic mechanism of the scientific endeavor. It has produced advancements in our common knowledge of the marine realm allowing society to make better informed decisions (Fischhoff and Scheufele, 2013). Research centers, universities and individual researchers have fostered technology transfer for problem-solving, aiming at progressing in scientific

[3]http://portete.invemar.org.co/chm, accessed on January 27, 2021.



discovery. Agreements signed between research institutions and universities often include the exchange of human capacities and technology transfer at some level (Dolan, 2012). Drivers of such agreements are opportunities presented by the growing internationalization mechanisms adopted by those institutions (Qiang, 2003). Such mechanisms aim at projecting national capacities and competencies abroad to attract human and financial capital for further institutional developments, as a form of investment. In the context of Latin America and the Caribbean, internationalization has also provided the means to access foreign research funding and assets, placing an important opportunity to foster partnerships, but also to overcome national budget constraints.

This practice is more common in the context of technologies developed by publicly funded research, mainly targeting scientific discovery. Privately funded research assets, in particular those aimed at exploring the marine resources such as oil, fisheries and minerals, are less common on those agreements because these technologies raise industry's competitiveness and profit (Ruffini, 2020a). There are, however, a few privately funded organizations that use advanced technologies to promote open access information to society [e.g., Global Fishing Watch (Nugent, 2019)].

It is therefore fundamental that scientific cooperation in informal pathways is continued and promoted so science can profit from the free thinking and foster technology transfer. In fact, diplomacy should acknowledge and promote these informal channels where applicable, supporting actions that have been successful over time, such as cooperation agreements between research institutions. This informality is addressed as a form of Track 2 diplomacy in International Relations scholarship. The term can be understood as a parastatal informal diplomacy in which stakeholders are not necessarily bound to Governments (Jones, 2015). Track 2 diplomacy can use the science international cooperation to progress on addressing community and common interests in a more flexible way than the official, Government-led track 1 diplomacy. At the end of the day, both forms of negotiations should be interlinked and supportive of one another if we are to see change in the transfer of marine technologies during the Decade of Ocean Science, for example.

Intellectual Property Rights (IPR)

The overarching difficulty for an intergovernmental body such as the IOC to pragmatically propose the transfer of marine technologies lays partially on issues of Intellectual Property Rights (IPR) (Zhou, 2019). Unlike the provisions on TMT, MSR and capacity development, under the scope of the LOSC and the mandate of institutions connected with this regime, IPR in under the mandate of the World Intellectual Property Organization (WIPO) and the World Trade Organization (WTO), through the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). Indeed, as the LOSC is not a stand-alone treaty, it interacts with other regimes of international law, and has mechanisms to do so (Trevisanut et al., 2020), as for instance the above-mentioned article 267. Nonetheless, the conversation between these regimes has so far only favored private companies detaining patents.

In light of global environmental conundrums, WIPO was challenged to balance "the free transfer of technologies and sustainable innovation", but without much success (Zhou, 2019). Similar process is undergoing in the WTO, and negotiations on technology transfer under the scope of TRIPS have not been evolving (Zhou, 2019). Therefore, traditional diplomacy has been unable to reach consensus on how to balance IPRs and public interests to advance sustainability (Latif et al., 2011).

Private Sector Involvement

Companies take risks and make investments to profit from technological assets. The private sector alone should not be accountable to make change by opening patents and handling technology blueprints. In addition, countries in Latin America and the Caribbean will benefit little from blueprints if they do not possess the necessary human capacities and physical facilities to develop marine technologies. Therefore, an intergovernmental coordinated effort needs to be developed by finally operationalizing the clearing-house mechanism of IOC to then match technology holders and needs (Harden-Davies, 2016). Second, public diplomacy needs to foster a discussion on the possible trade-offs for the private sector to join in this effort. Companies can profit from opening new markets and investing in capacitating new labor in the region. Third, local governments need to invest in innovation policies and start-up programs to absorb the technology being transferred. Local business might then flourish, and local realities will adapt technologies to their needs, feedbacking the innovation process at a larger scale. At the end of this complex process, countries can begin to negotiate the co-development of technologies, beyond the scope of transferring technology as a passive-active relationship (Chesbrough and Schwartz, 2007). Although there are conflicting views addressing market competition and sustainability, there are also opportunities to leverage this relationship, such as private

research programs on marine ecosystem restoration or pollution (Virdin et al., 2021).

Private companies' interests are considered by diplomacy when defending national positions in international negotiations. Same applies to public interest, as the societal benefit of a healthy and safe ocean environment. Thus, diplomacy needs to balance community/public interest with those interests coming from specific groups or countries. This complex relationship between national interests and global public goods involving science and technology is taken under the scrutiny of science diplomacy research (Ruffini, 2020b). Moreover, a better coordination between international regimes such as LOSC, WIPO, and TRIPS is highly desired. The Decade of Ocean Science should open this dialogue by confronting diplomatic negotiations in both regimes and searching for opportunities. A simple recommendation in this issue would be to align country's representations in both process with the aim of finding common grounds for opening this frank debate on Intellectual Property Rights.

DISCUSSION

The United Nations Law of the Sea Convention and related implementing instruments have set rights and obligations able to reduce worldwide asymmetries in the access to scientific knowledge and marine technology. Nevertheless, in spite of some increase in the participation of Asian countries in scientific publications, mentioned in the latest Global Ocean Science Report, the scientific and technological capabilities remain inequality distributed. Developed countries still concentrate the majority of ocean science human capacity and more incentives for researchers, like the access to international forums and networking (IOC-UNESCO, 2020a). Equally, only five countries in the world, all located in the global north, have full wide range access of technological infrastructure, with only a few others with capacity to conduct open waters and deep-sea research (IOC-UNESCO, 2020a). For instance, none of the Small Island Developing States (SIDS), which includes the Caribbean States, have deep-research vessels.

The origins of many of these difficulties in promoting the right of access to scientific knowledge and technology to developing countries lye in historical processes of colonization (Headrick, 1981). Additionally, from an epistemological perspective, science is a western invention, as so, from the starting point developing countries need to follow theories and methods founded in an alien mindset, still being under dispute how to integrate traditional and indigenous knowledge in the science-making (Weiss, 2005; Mulalap et al., 2020). This topic assesses whether science diplomacy is an appropriate tool to reduce scientific and technological asymmetries without disregarding the compelling reasons for a deeper discussion.

Science Diplomacy Facilitating the Transfer of Marine Technologies in Latin America and the Caribbean

Latin America has experienced a raise in social sciences' research in understanding the role of Science in advising policy, with a prominent focus on "center-periphery" relations in scientific research and the globalization of the social sciences, or the ownership of knowledge, particularly indigenous knowledge, when compared to the United States and Europe (Echeverria et al., 2020). Historically the theoretical field of International Relations (IR) has dealt with technology in both an optimistic and a skeptical conflict, in particular scholarship around the role of technology in the Cold War. Science and Technology was placed exogenously in theoretical IR and the dynamics and global impacts of Science needed further empirical evidence. Today, IR is seeking ways to incorporate the global politics of science and technology as a distinct subfield, which is by default an interdisciplinary approach that needs to include other fields of social sciences therein (Koh and Jayakumar, 1977). Therefore, science diplomacy can offer a new interdisciplinary approach to study how science and technology, its multiple facets and understandings, can influence international relations (Lidskog, 2014). We frame this discussion around the taxonomy provided by (The Royal Society, 2010) so the organization reflects the general science diplomacy literature.

First, "Diplomacy for science", which stands for diplomacy facilitating international scientific cooperation by leveraging investment and prioritizing research to address uncertainties in decision-making. Here, diplomacy can set official frameworks by which countries can access marine technologies, such as through the IOC. By doing so, diplomatic negotiations can foster the establishment of international cooperation on fair and equitable grounds, in accordance with the Law of the Sea Convention. Moreover, diplomacy needs to integrate debates going on in different fora, in particular among WTO and WIPO, on how to deal with intellectual property rights. In addition, diplomacy can foster an arrangement between the public and private sector regarding the access and application of relevant technology to research global public goods, such as the ocean. Ocean science can only progress in an equitable manner if access to marine technologies is granted on an equitable basis through the diplomatic decision making. Thus, diplomacy for science in this scenario means intergovernmental negotiations to grant access to marine technologies and capacity development.

Second, "science in diplomacy", that deals with the provision of scientific evidence to support international decision-making. Research will be responsible to inform diplomacy on the above mentioned negotiations. Knowledge gaps and trending themes of concern need to be communicated in such a way that diplomacy can discuss institutional and legal arrangements to overcome current obstacles for an effective transfer of marine technologies. Scientists have a pivotal role in clarifying what should be the results in effective marine technology transfer, highlighting the current pathways to acquire technologies and barriers, such as Intellectual Property, maintenance and operating costs. Non-governmental organizations and intergovernmental organizations shall play an important role in this regard (Lidskog, 2014). For example, the organization of public debates among scientists using the networks under NGOs are theme-oriented and independent from States and formal diplomacy, resulting in a flexible approach to discussing the

state-of-the-art research and potential future actions. In ocean affairs, NGOs have provided scientific expertize since the early negotiations of the LOSC (Koh and Jayakumar, 1977). Therefore, science in diplomacy will allow provision of knowledge gaps and current technology needs to properly advance in ocean sustainability to comply with global community interests.

Lastly, "science for diplomacy", in which international collaboration advances to bridge countries and build a constructive dialogue through joint research projects. The utmost example of such is the adoption of the UN Decade of Ocean Science. The Decade is hoped to be the long-waited opportunity for research to bridge countries and people around a common goal. Different stakeholders with diverse values and needs shall inform the Decade's process on achieving societal goals of ocean sustainability (Claudet et al., 2019). The Decade's *raison d'être* is to put ocean science in service of society, including policy making, despite any possible tension between countries in other international debates. Thus, science for diplomacy will act to allow this dialogue between countries and stakeholders to take place through joint regional/global research efforts, that can be fostered initially by informal pathways, attained to the Track 2 diplomacy practices.

Ultimately, the balance between national political interests and global community interests in transferring marine technologies to foster ocean sustainability is a matter of balancing competition versus cooperation (Ruffini 2020b). There must be an optimal point in which trade-offs are made and commitments are adopted. This point must be achieved by addressing both the issues of national priorities, such as industry development and labor enhancement, with those of global concern, such as marine environmental protection and ecosystem service restoration. In this regard, scientists become yet another social group with intrinsic values and interests (Jasanoff, 1987; McCain, 2016, pp. 253-257). Therefore, progressing in understanding the social dynamics within the group of scientists and between scientists and diplomatic relations becomes essential to better inform global processes based on scientific evidence, such as the UN Decade of Ocean Science (Rose, 2018). Science diplomacy research in this regard, and in particular in the context of Latin America and the Caribbean, the region's gaps and priorities, will enhance the global discussion to implement the Decade.

Examples of Science Diplomacy Processes Leading the Transfer of Marine Technology

Peer-to-peer cooperation agreements between research institutions and universities generally include the exchange of human capacities and technology transfer at some level (Dolan, 2012). Drivers of such agreements are opportunities presented by the growing internationalization mechanisms adopted by those institutions (Qiang, 2003). Internationalization of universities and research centers is one of the outcomes of the globalization of science.

A good example of such is the cooperation between research institutions from Germany and Cape Verde to create and operate an ocean research center in Cape Verde (Kaehlert et al., 2017). The Ocean Science Center Mindelo results from a formal agreement between the GEOMAR Helmholtz Center for Ocean Research and Cape Verde's Instituto do Mar—IMar. The Tropical portion of the Atlantic has a determinant role in the heat exchange between the ocean and the atmosphere, a feature that is central to understand global climate and ocean dynamics (Seidel et al., 2008). German scientists wish to access an island in the middle of the Atlantic to further enlighten how the Tropical Atlantic influences the North. Germany benefits from relevant information and Cape Verde with the access to technologies and capacities to deal with their own waters. Moreover, the center is devoted on building capacities in Cape Verde so their ocean science community can be empowered. Ultimately, the German interest in Cape Verde contributed to the European Commission signing a diplomatic bilateral science and technology agreement on ocean research as a part of a broader ocean science diplomacy arrangement for the whole Atlantic basin (Polejack et al., 2021). This ocean science diplomacy practice has balanced the capacity needs of Cape Verde with the German interests in the region advancing knowledge production that will be fit for the global ocean assessment purpose, fully implementing articles 244, 266 and 275, LOSC.

Another good example of science diplomacy aiding countries to implement their international obligations in the transfer of marine technologies is the global ocean observation network. Ocean observations are highly dependent on technology and, under the auspices of IOC's Global Ocean Observing System (GOOS) cooperation has been key to deploy equipment worldwide, such as buoys, drifters and other ocean monitoring instruments (Tanhua et al., 2019). In general, this cooperation involves the exchange, maintenance and calibration of equipment from one country to another. The handling of equipment's blueprints for local development and manufacture is much rarer. Among the practical examples of our knowledge is the development of the Atlas-B buoy in Brazil (Campos et al., 2014). The U.S. National Oceanic and Atmospheric Administration (NOAA) freely handed the blueprints of their Atlas buoy technology for development in Brazil. As a result, Academia and industry partnered to develop an adaptation of this equipment, which was deployed in face of Brazil for testing. In spite of formal Government agreements in this matter, both NOAA and the University of São Paulo together with two Brazilian companies were able to successfully transfer a key technology nonexistent in the country before. Capacities were developed and today Brazil is able to progress in the manufacture of this buoy.

From the above mentioned, science diplomacy as a practice provides different perspectives of implementing the international obligations of transferring marine scientific knowledge and technology, reducing inequalities and empowering developing countries. Practical examples support this perspective, although the Decade will be a more ambitious stage for the science diplomacy interplay.

CONCLUSION

Marine researchers in Latin America and the Caribbean struggle to conduct state-of-the-art research mostly due to the lack of

permanent funding, appropriate scientific capacities and access to marine technologies. Consequently, these countries are challenged to contribute with scientific evidence in current ocean affairs, such as the BBNJ negotiations (Harden-Davies and Snelgrove, 2020). Although the global ocean governance framework provides the legal and institutional support for the transfer of marine technology from developed to developing countries aiming at strengthening local and regional capabilities, after decades of the entry into force of LOSC, part XIII and part XIV are considered among the least implemented of the LOSC (Long, 2007; Long and Chaves, 2015).

The globalized research community has provided informal venues for the transfer of marine technology. However, these peer-to-peer relationships will not be sufficient to achieve the equity that several States have called for to strength national capacity permanently to meet national needs and international standards. Therefore, this paper presents some concrete recommendations on how countries in Latin America and the Caribbean can enhance their national scientific capacities by using science diplomacy as a tool to foster beneficial international deals.

First, according to the requirements of the LOSC and the Resolution on the development of national marine science, technology and ocean service infrastructure (A/CONF.62/120*), developing countries must produce science and technology needs assessments, by which gaps and priorities shall be apparent. Such an effort could be supported by international organizations, the scientific community and research organizations, including from the private sector, together with governments.

Second, efforts must be taken to effectively implement the clearing house mechanism as per the IOC guidelines (IOC-UNESCO, 2005). Major technology holders from the developed world and representatives from organizations with mandate related to intellectual property, such as WTO and WIPO, should be included in discussions on the of such a clearing house mechanism, providing inputs and other perspectives. Issues related to exchange rate, taxation, fees for transportation, and limits to comply with standards for ocean observation should be considered in the clearing house mechanism. Additionally, it is relevant to discuss about incentives to create regional certified laboratories in developing countries to provide maintenance and calibration for equipment, as well as reviewing the standards for accreditation. Latin America and the Caribbean can profit from the trial version of this mechanisms that IOC has initialized in the region.

Third, a shift in vocabulary may represent a positive change on how developed countries understand their role in promoting scientific and technological equity. Using terminologies such as co-development of technology instead of transfer are able to build more linear relations between stakeholders and reduce perspectives of subservience (center-periphery).

The Decade of Ocean Science shall be a good opportunity to foster the debate around effective manners to progress in granting opportunities for developing countries to access marine technology and capacity development, by implementing the regimes enshrined in part XIII and XIV of the LOSC. Countries in Latin America and the Caribbean have the opportunity during this Decade to push for improvements in the access of marine technologies. The provisions in the LOSC and related instruments give the legal basis for this discussion. Moreover, ocean science diplomacy can provide the necessary insights on possible negotiations based on evidence and favoring fair and just transition pathways.

AUTHOR CONTRIBUTIONS

AP conceived and drafted the first version. Both authors contributed to the writing of the manuscript, co-developed the recommendations and approved the paper's final version.

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Corrigendum: Ocean Science Diplomacy can Be a Game Changer to Promote the Access to Marine Technology in Latin America and the Caribbean

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In the published article, there was an error. A correction has been made to the **Affiliation 3**.

Instead of "Research Group Natural Resources, Law, and Sustainable Development, Brazilian Institute for the Law of the Sea, *Caxias do Sul*, Brazil," it should be "*Research Group Natural Resources, Law, and Sustainable Development, Brazilian Institute for the Law of the Sea, Salvador, Brazil*."

The authors apologize for this error and state that this does not change the scientific conclusions of the article in any way. The original article has been updated.

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PERSPECTIVE
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Bringing Policymakers to Science Through Communication: A Perspective From Latin America

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Scientific knowledge should be shared beyond academic circles in order to promote science in policymaking. Science communication increases the understanding of how the natural world works and the capacity to make informed decisions. However, not every researcher has the ability to master the art of communicating, and even less in a clear, concise, and easy to understand language that society representatives appreciate. Within the huge and extraordinarily diverse Latin American region, science communication has been going on for at least 200 years, when the first science stories appeared in the newspapers, as well as the first science museums and botanical gardens were founded. Nevertheless, resources are limited, and notably time, which researchers spend mostly in mentoring, ensuring funding, publication of their results and laboratory work, while science journalists are an endangered species. This perspective article aims at providing some recommendations to build bridges between science and decision-making parties through communication, by exploring how Latin American diplomats and policymakers engage with scientific knowledge.

Keywords: science communication, science advice, Latin America, science diplomacy, evidence-base for policy

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INTRODUCTION

In its 27th Article, the Universal Declaration of Human Rights states that "Everyone has the right freely [...] to share in scientific advancement and its benefits." Scientific knowledge empowers citizens by increasing their capacity to make informed decisions and strengthens democracy by promoting debate. Understanding the scientific method allows people to question the trustworthiness of the information sources and to deal with uncertainty, which ultimately helps to fight the spreading of misinformation (Awandare et al., 2020). Thus, scientific dissemination is not only a right, but also a duty (Lopez-Goñi, 2020).

Science and technology have become crucial tools to tackle the grand challenges of humanity. However, no matter how hard researchers work if their insights do not catch properly the attention to those who have the power to take real actions. The lack of a speaking ground language hinders communication and collaboration between scientists, diplomats, and policymakers. Furthermore, whereas the scientists complain about the low knowledge and interest in the science of the policymakers, the latter blame the researchers for not working on relevant projects and not supplying the information they needed immediately (Janse, 2008).

Latin America is a huge and highly diverse region, with important socioeconomic and cultural differences among countries. There is also a tremendous disparity in scientific production. But even

rich Latin American nations do not produce a good level of science, as a result of the negative environment created by political leadership, rather than the lack of talent or creativity (Ciocca and Delgado, 2017). Despite this disadvantage, in countries like Brazil, Argentina, or Colombia, scientific journalism began as early as in the 19th century, when scientific and technological advances appeared within the pages of the first printed newspapers, even before there was a recognizable academic scientific community within the region (Vessuri, 1994; Fog, 2004; Nowak, 2008; Massarani, 2010). Science and natural history museums, as well as botanical gardens, have also a long history, existing in Brazil, Mexico, or Uruguay for more than 200 years (Vessuri, 1994; Massarani, 2015; Sánchez-Mora et al., 2015). However, it was not until the 1960s, when scientific communication gained relevance as part of a growing educational movement that sought to increase the scientific culture of the population, in several Latin American countries (Massarani et al., 2015).

A substantial body of literature identifies communication as one of the key skills for successful evidence-informed policymaking and to close the gap between the so-called "two communities" (Tseng, 2012; Akerlof et al., 2018; Topp et al., 2018; Yanovitzky and Weber, 2018; Zdunek et al., 2021). Langlois et al. (2019) found that adequate communication incentives and training of human resources were the main facilitators to embed research into policy, in eight Latin American and the Caribbean countries.

In this perspective, we aim to provide recommendations on how to bring Latin American policymakers to science through communication by combining insights from relevant stakeholders in the region with previous findings and from the personal opinions of the authors based on their own experience.

LISTENING TO THE STAKEHOLDERS

There is a consensus that scientific knowledge does not reach decision-makers properly. About 78% of diplomats and policymakers as well as 89.8% of researchers and science journalists agreed with this statement, in an online survey distributed within Latin America, from September to November 2020 (**Supplementary Methods**).

The first questionnaire, designed for diplomats and policymakers got 225 participants, whereas the questionnaire of researchers and science journalists was answered by 362 people (**Supplementary Tables 1–4** for demographic information of the respondents). More than 75% of diplomats and policymakers represented Colombia, Panama, Costa Rica, Argentina, Brazil, and Mexico (**Figure 1A** and **Supplementary Table 5**), whereas they were mostly working in Panama, Colombia, Argentina, Europe, Costa Rica, Brazil, Mexico, and Uruguay (**Figure 1B** and **Supplementary Table 6**). As far as researchers and science journalists are concerned, most of them were settled in Panama, Mexico, Argentina, Colombia, Chile, and Brazil (**Figure 1C** and **Supplementary Table 7**).

Although responses were obtained from almost all Latin American countries, we are aware that the sample does not represent the region homogeneously. But data on science communication efforts targeting Latin American policymakers are scarce. Thus, we prefer to listen to stakeholders in the region, even partially, to elaborate recommendations tailored to the real problems they face when communicating, instead of writing a theoretical assay based solely on the experiences of non-Latin American countries.

PREPARING TO REACH POLICYMAKERS

Many scientists have a strong motivation to increase the impact of their work, and to engage with policymakers, although they might not know how to start. Among our questionnaire respondents, 58.6% of researchers and science journalists declare to interact with diplomats and policymakers, on a biannually (44.4%), monthly (29.5%), and weekly (12.6%) basis. Catching their attention or even getting an answer could be quite challenging, as experienced by ourselves when distributing our survey. However, correctly identifying the who, when, and how improves the chances of success (Cairney and Kwiatkowski, 2017; Topp et al., 2018).

Reaching policymakers who have science issues on their agenda is much easier than getting an answer from others devoted to other interests. In our research, we have found that many Latin American countries provide information regarding draft laws, initiatives, and commissions in which decision-makers take part, on their Parliamentary website. It might be worth visiting to identify the target of whom to communicate science.

A common practice within the policy is lobbying (Thomas and Klimovich, 2014). So, diplomats and policymakers can be quite suspicious when receiving a "cold call." From our experience, being honest about goals and motivations increase the likeliness they trust and listen to you, as do recommendations. Talking to those around and establishing a valuable network of contacts can help close the gap between science communicators and decision-makers, too.

Timing is also important. While researchers usually work on long-term projects, time in policy is counted in months and is heavily impacted by electoral calendars. Therefore, we would not advice researchers to approach policymakers while campaigning. However, meeting at the beginning of a policy term, when priorities are being set, is quite effective (Safford and Brown, 2019).

Latin American researchers, science journalists, diplomats, and policymakers prefer email as an ice-breaking communication channel (**Figure 1D**). It works on regular communications too (**Figure 1E**). Personalized subjects and salutations are a must to get attention, while email addresses can be found on many Latin American official and governmental websites. Once the parties know each other, video calls, instant messaging, phone calls, and face-to-face meetings can reinforce communication (**Figure 1E**).

COMMON INTERESTS, BUT DIFFERENT PRIORITIES

It is often said that science and policy are far away from each other and that researchers and policymakers are strange bedfellows with little or no common interests (Lucente, 2017). However, it might not be entirely true. According to our survey

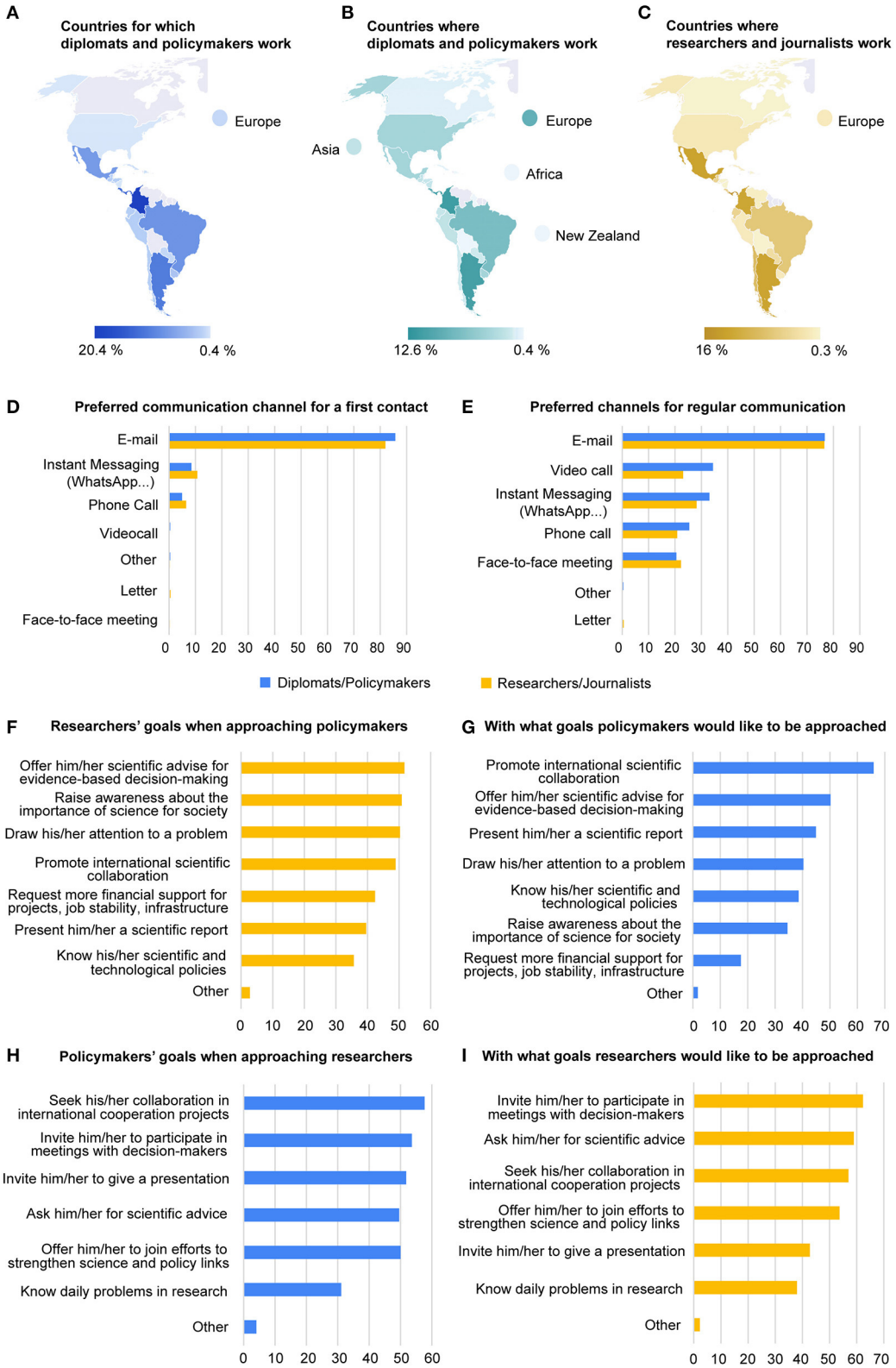

FIGURE 1 | (A) Countries for which diplomats and policymakers work. **(B)** Countries where diplomats and policymakers carried out their professional activity. **(C)** Countries where researchers and journalists carried out their professional activity. **(D)** Preferred communication channels to stabilize a first contact according to

(Continued)

FIGURE 1 | diplomats and policymakers (blue), as well as researchers and science journalists (yellow). **(E)** Preferred channels for regular communication as reported by diplomats and policymakers (blue), as well as researchers and science journalists (yellow). **(F)** Goals of researchers and science journalists when communicating with diplomats and policymakers. **(G)** Reasons why diplomats and policymakers would like to be reached out by researchers and science journalists. **(H)** Goals of diplomats and policymakers when communicating with researchers and science journalists. **(I)** Reasons why researchers and science journalists would like to be reached out by diplomats and policymakers. All data are shown in percent.

results, researchers and policymakers may indeed share goals, but prioritize them differently. For instance, the main objectives of Latin American researchers when approaching policymakers include, "offering scientific knowledge for evidence-based decision-making," "raising awareness about the importance of science in society," and "drawing policymaker's attention to a problem" (**Figure 1F**). However, at first, the policymakers would like to be approached to "promote international scientific collaboration," (**Figure 1G**) something researchers rank as their fourth priority.

Differences also arise the other way around. In the first instance, Latin American diplomats and policymakers would contact researchers to "seek their collaboration in international cooperation projects" (**Figure 1H**). Secondly, they would "invite researchers to participate in meeting with decision-makers," which represents the main interest of researchers when reached by diplomats and policymakers (**Figure 1I**). Policymakers would also like to "invite researchers to give a presentation" (**Figure 1H**). However, researchers would prefer to be reached out to "ask them for scientific advice" (**Figure 1I**). Finally, the one and the other rank "decision-makers gain first-hand knowledge of daily problems in research" as the least important input. The low priority given by researchers to this issue has surprised the authors.

Nevertheless, it is worth noting that regardless of how both parties ranked the inputs, even the lowest rated got a significant percentage of attention. This, in our opinion, means that there are indeed common interests to start building a dialogue, even if it is not always easy or successful.

SEEKING COMMON COMMUNICATION CHANNELS

Most common difficulties faced by the Latin American researchers and science journalists when engaging with diplomats and policymakers are lack of interest or time, as well as scientific illiteracy and ignorance on the relevance of science to decision-making. Mistrust also pervades Latin American scientists who fear the misuse of their data to support political and economic interests. Although a scenario where every decision is based on evidence is quite unrealistic, because uncertainty is intrinsic to science that does not have every answer, there is a common demand among Latin American researchers to increase science influence in policy. To achieve this goal, many of them stated that science communication could be a facilitator.

Significance and usefulness of scientific data are limited, if not shared. Thus, whether in peer-reviewed journals or scientific meetings, researchers spend most of their academic career in communicating their knowledge. However, policymakers are not always good at reading a scientific paper, because it is not their job (Streubel, 2018). Latin American diplomats and policymakers would rather attend conferences to get information about scientific and technological advances (**Figure 2A**). Conferences are also the preferred media of researchers and science journalists to communicate science (**Figure 2B**). Nevertheless, we advise on not giving a long talk, with the vocabulary and format of a scientific conference, before a busy decision-maker, since it will hardly have any impact and will probably end in failure.

Communicating to a non-scientific audience requires training, something that interviewed Latin American researchers claim to miss. This is reflected in their little use of generalist media as a speaker, in spite of recognizing that newspapers are one of the main sources of information used by decision-makers (**Figures 2A,B**). Informative videos also require some specific skills, but the reward is worth the effort. Images are a particularly efficient method of communicating information, which allow conveying of large amounts of data in a relatively short space of time (Pasquali, 2007). So, considering that diplomats and policymakers have busy and awkward lives (Docquier, 2017), the high marks they give to videos are not surprising (**Figure 2A**). Latin American researchers and science journalists also account for the usefulness of videos (**Figure 2B**). They not only make it easier to explain complex and tedious manuscripts (Darzentas et al., 2007), but also constitute an effective way to portray an accurate view of how science gets done, as well as some of the interesting places where scientists work (Pasquali, 2007). However, a document that specifically addresses the interests and the needs of policymakers is largely ignored by Latin American researchers and science journalists (**Figure 2B**). Policy briefs give concise, objective summaries of relevant scientific data, as well as recommendations, aimed to help readers decide what they should do (DeMarco and Tufts, 2014). We encourage the Latin American scientific community to communicate through this channel to bring research into policy.

WHO IS TWEETING?

Social media deserve a special mention, since they provide researchers with one of the most direct routes for sharing their work, as well as reaching practitioners and the general public. In fact, Latin American diplomats and policymakers make extensive use of social media to obtain information on scientific issues; especially, Twitter (**Figure 2C**). Communicating science through Twitter is a challenge, as it requires condensing complex messages into very little space. Still, together with Facebook, it is the most used social media by Latin

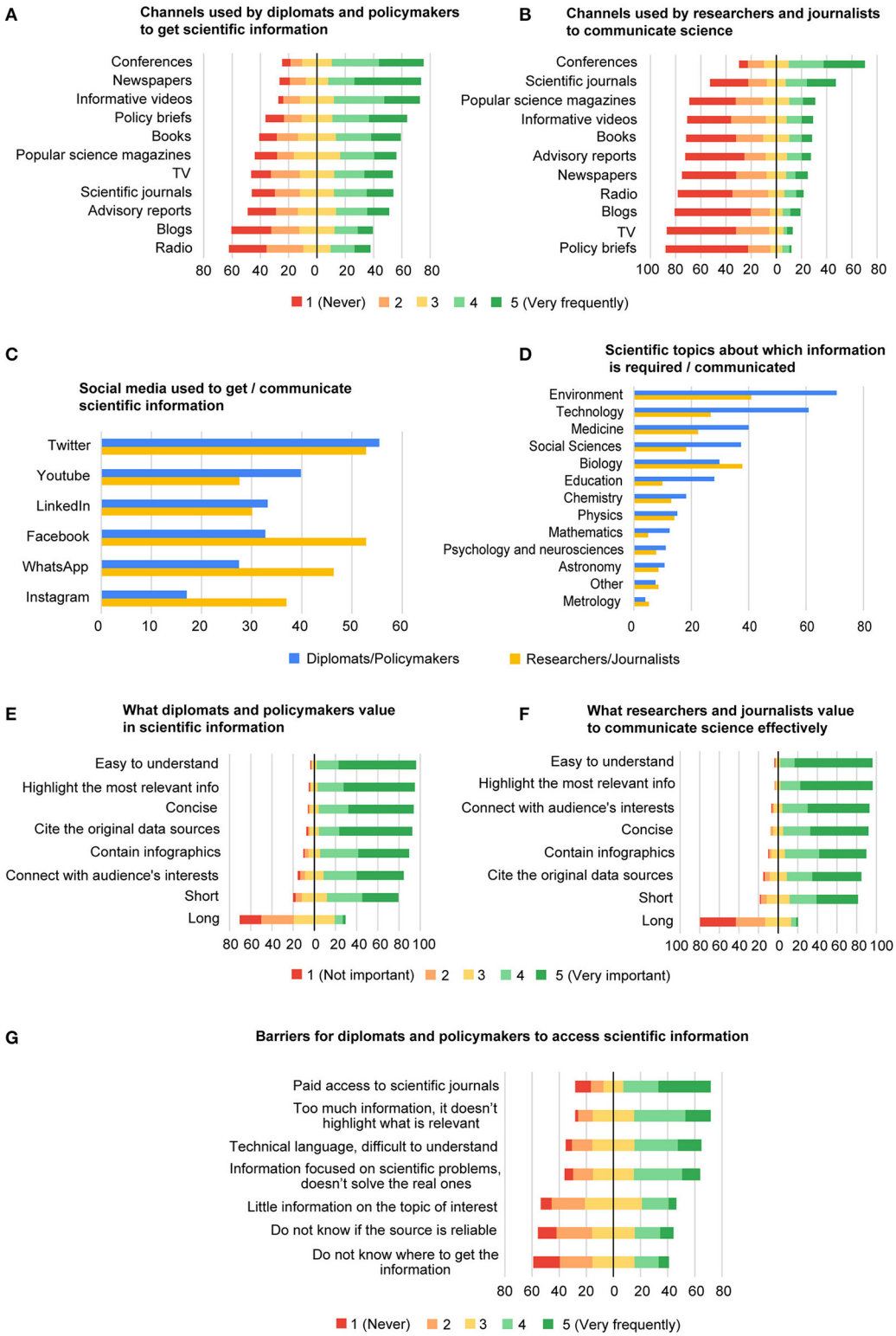

FIGURE 2 | (A) Frequency at which diplomats and policymakers use various communication media to obtain information on scientific and technological advances, in their work. **(B)** Frequency at which researchers and science journalists communicate science on various communication media. **(C)** Preferred social media to get scientific information (diplomats and policymakers, blue) and to communicate science (researchers and science journalists, yellow). **(D)** Scientific topics about which diplomats and policymakers need information (blue) and researchers and science journalists focus on when communicating (yellow). **(E)** What diplomats and policymakers value more or less in science information. **(F)** Factors, the researchers and science journalists think are more or less important for effective science communication. **(G)** Frequency at which diplomats and policymakers face different barriers when trying to acquire scientific information. All data are shown in percent.

American researchers and science journalists to spread their knowledge (**Figure 2C**).

Twitter is an ideal tool for broadcasting, but even more so for listening and discussing. Therefore, we encourage Latin American researchers and science journalists to take advantage of this social network to connect with people (e.g., diplomats and policymakers), beyond those who share their opinions and interests. That is, to avoid falling into the so-called "echo chamber" to increase the impact of their message. Furthermore, tweeted articles achieve higher citation rates, which suggest a wider reach also among scientist peers (Klar et al., 2020; Luc et al., 2021).

YouTube is the second most visited website globally and also the second most popular social network, with more than 1,500 million users, after Facebook (Fernández Bayo et al., 2019). Considering the fact that Latin American diplomats and policymakers use informative videos as scientific information sources, it comes as no surprise they rank YouTube as their second-most used social media (**Figure 2C**). What is quite shocking is that it is the least one used by Latin American researchers and science journalists. Certainly, in our opinion, it is an aspect to correct and improve.

There is also little agreement on the preferences of both parties with regard to the use of LinkedIn, Facebook, WhatsApp, and Instagram (**Figure 2C**). However, for us, it is worthy to take advantage of any opportunity to communicate. Thus, this should not discourage researchers from learning and adapting their message to each social network in order to engage with decision-makers.

BRINGING SCIENCE TO POLICYMAKERS

To be effective, science communication should cover the needs of the audience (National Academies of Sciences, 2017). In Latin America, diplomats and policymakers request information about environmental issues (**Figure 2D**). Since the region faces many challenges, from forest fires that devastated much of the continent, to contamination of soil and water resources, or the vulnerability of Central America to natural disasters aggravated by climate change, the environment is also the main topic communicated by researchers and science journalists. Interestingly, when addressing this issue, Latin American researchers and policymakers can find a common ground language, quite easy. Noticing that, our survey shows that policymakers demand information on a wide variety of topics, which we see as an opportunity for researchers to advice policy.

And when doing so, translating research findings into simple, but not simpler, easy to understand language is a necessity for evidence communication (Gregrich, 2003). Highlighting the most relevant information, along with coming to the point, that is, being concise using few and adequate words, is what Latin American diplomats and policymakers value most in scientific information (**Figure 2E**). According to the personal experience of the Latin American researchers and science journalists, considering their audience interests when disseminating science is a key to ensure successful communication (**Figure 2F**). Interestingly, both parties are unanimous in rating what makes science communication effective (**Figures 2E,F**), which suggest that finding a common language to put research on use is indeed possible.

At this point, it seems evident that Latin American diplomats and policymakers are interested in science, or at least part of their community. However, they often face paywalls when trying to access original manuscripts. Moreover, to the excess of irrelevant information and the incomprehensibility of technical language, they add the difficulty of finding research that responds to policy questions and social concerns (**Figure 2G**). Therefore, although it is true that there is a difference at the educational level between researchers and policymakers (**Supplementary Tables 8**, **9**), the latter are not illiterate. Hence, in our opinion, they might just need a bridge to the scientific community.

DISCUSSION AND CONCLUSIONS

Successful communication of science serves as a prerequisite for the successful use of science in policy (Akerlof, 2018). In the last few decades, science communication has grown significantly in Latin America. Internet and social media have greatly contributed to it, but there is still a long way to go (Massarani, 2018). Most Latin American research institutions have a limited budget devoted to science communication activities. Barba et al. (2019) found that only 10% of their staff undertaking science communication activities were professionals and, of them, only 35.6% made it on a full-time basis. This is in accordance with our results, as 73.9% of researchers declare to be volunteers, and not always being paid for their dissemination. Moreover, in our survey, science journalists claim being an endangered species in the midst of a media crisis, aggravated by difficult economic times, where coverage of science is considered expendable and, if necessary, carried out by non-specialist reporters.

There is a common consensus among Latin American researchers, science journalists, diplomats, and policymakers that scientific knowledge does not adequately reach decision-makers. That gap relates primarily to what is sometimes described as the "two communities" problem, and the key differences in their practices, rules, expectations, incentives, and language (Gaudreau and Saner, 2014). No simple answer exists to deal with this problem, but communication is one of the most cited skills to address it (Cherney and Head, 2010; Leshner, 2012; Akerlof et al., 2018; Topp et al., 2018).

After interviewing fifteen US Congress members, Akerlof et al. (2018) identified complexity, evidence inconclusiveness, accessibility, presentation, and lack of data transparency as barriers to the use of science in policy. The review by Oliver and Cairney (2019) on 145 studies found that access to information, clarity, relevance, and reliability of findings limit the use of evidence in health policy. These results align with the most frequent impediments that Latin American policymakers report facing in obtaining scientific information (**Figure 2G**).

What Latin American diplomats and policymakers value most in scientific information is that it is easy to understand, followed by hitting the main points and being concise (**Figure 2E**).

Accordingly, some authors indicate the use of specialized language and scientific jargon as the reason why academic research often misses the attention of the policymakers (Feldman et al., 2001; Hemsley-Brown, 2004). They also highlight the importance of the way information is presented and the usefulness of visual formats, such as infographics or videos, which also attract Latin American policymakers, based on their use of informative videos and YouTube.

There is a groundswell of opinion, and the authors share their vision, that advocates the need to understand the audience to communicate science effectively (Cairney and Kwiatkowski, 2017; Davidson, 2017). Latin American policymakers report receiving too much information and not knowing how to identify which information fits their needs. Researchers are responsible for the way they present their data to reduce the burden on policymakers and facilitate their implementation in the decision-making process. In this sense, researchers should make use of the power of telling stories, documented in gray literature, to facilitate the memorization of information. Davidson recommended the Smart Chart (Spitfire Strategies, 2017) as the first step to build a communication strategy, along with the Message Box Workbook to extract the most relevant parts of the scientific message.

Researchers should also understand the timing and the real-world policymaking, far from the rational and orderly scientific cycle, as well as the use of science for policy, to tailor their message. Researchers often hope for instrumental use, wherein science directly influences a policy (Tseng, 2012). When questioned about this topic, Latin American researchers bemoan political or symbolic uses, in which research is used to justify a position that has already been fixed. But not infrequently, the use of information may actually occur after the decision has been made. Here, the elaborative use can refine the already defined position, whereas the strategic use serves to reconfirm it (Akerlof, 2018). Researchers can also influence how policymakers think about problems or potential solutions (i.e., conceptual use) (Tseng, 2012).

After analyzing the responses of Latin American researchers and policymakers, we concluded that there is a general lack of knowledge of the other's world. We recommend bringing both parties together to discuss common issues to improve communication. Cross-training seems to facilitate collaboration by stabilizing mutual understanding of language and values (Gaudreau and Saner, 2014). Accordingly, we highlighted initiatives, such as the science, technology, policy (STeP) Fellowship Program held by the Inter-American Institute for Global Change Research, within the Latin American region, whose fellows engage first-hand with policymakers. We also encourage researchers who are concerned about improving their science communication skills to enroll in training programs (see Massarani et al., 2016 for an overview of the current postgraduate opportunities existing in Latin America).

Latin America has the potential to build bridges between science and policy. However, further research collecting testimonies, failures, and success stories in the region is needed to provide the best practices and guidance to improve communication between researchers and policymakers. In this perspective, we aimed to give a general, descriptive overview of the region that serves as the first step. But effective application and adoption of evidence-based approaches require identification of "what works for whom in what circumstances" (Cherney and Head, 2010). This makes it difficult to duplicate strictly between countries and highlights the need to study each region in particular.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation upon request.

AUTHOR CONTRIBUTIONS

MP-S conceived the idea, designed the questionnaires, distributed them, analyzed the data, and wrote the initial manuscript. FACM approved the questionnaires, distributed them, supervised data analysis, and extensively revised the paper. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frma.2021.654191/full#supplementary-material

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The Institutional Building of Science and Innovation Diplomacy in Latin America: Toward a Comprehensive Analytical Typology

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Science and Innovation Diplomacy (S&ID) has emerged in recent years as a relevant scholarly movement and interdisciplinary research agenda internationally. This field is promoting a significant impact on the understanding of the cultural and political dynamics of Science, Technology and Innovation (ST&I), implementing initiatives from local to global level. Notwithstanding, S&ID is growing asymmetrically around the world, setting up over a particular configuration in the so-called Global South (GS) societies. In Latin America (LA), although S&ID is a recent, unequal and intra-nationally fragmented process, there are important achievements that have been able to create a favorable mix of approaches, agendas, and practices in this field. Addressing the scope of the special issue "Science Diplomacy and Sustainable Development: Perspectives from Latin America," this article aims to present a comprehensive analytical typology to the study of the emerging experiences of S&ID in LA, catching the diversity of this research agenda. This is a qualitative merged method-based study, sustained by a literature review, documentary research, online data analysis, and typology building. We understand S&ID in LA as a tentative re-organization of different states and subnational actors around the study and institutionalization of the governance of contemporary transformations on the systems of ST&I.

Keywords: Science and Innovation Diplomacy, science, innovation, institutional building, interdisciplinary, Latin America

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INTRODUCTION

Science and Innovation Diplomacy (S&ID) has been significantly impacting the understanding of the cultural and political dynamics of Science, Technology and Innovation (ST&I) over the last few years, from local to global level. We understand S&ID as a relatively recent scholarly movement and interdisciplinary research agenda addressing the study of how state and subnational actors interfere in the supranational governance of ST&I, as well as the idealization and management of tools of tentative governance regarding this field in different cultural settings. A relevant question about S&ID can be how those actors are capable of reconfiguring political and sociotechnical infrastructures to foster broader and more independent regimes of governance of science and innovation in different national contexts, by strengthening tools of international collaboration to sustain the potential of virtually permanent supranational initiatives.

However, there are multiple interpretations of what this field is or could be. As set by the "Madrid Declaration on Science Diplomacy" (S4D4C, 2019), "Science diplomacy (…) is understood as a series of practices at the intersection of science, technology and foreign policy." Moreover, according to the board of experts who signed this declaration, the contemporary interest in the S&ID debate "comes in response to identified challenges at the interface of science and foreign policy, where a greater scientific voice could both add value to bi- and multilateral discussions and decisions about our shared global concerns." As the paper shows, defining the concept of S&ID is, itself, an interesting intellectual exercise and admits several analytical dimensions, including behavioral, political–institutional, tentative governance, social/academic movement, and technoscientific networking.

Despite the development of well-known initiatives of S&ID in the European Union (EU), S&ID has been growing asymmetrically around the world. It motivated us to call attention to how this field has been built over a particular configuration in the so-called Global South (GS) societies. In those countries, S&ID shares both similarities and strong asymmetries in terms of its historical and political trajectories, governmental agendas, approaches to Science and Technology Policy (S&TP), regimes of knowledge production, infrastructures, etc.

In Latin America (LA), S&ID is a recent and intra-nationally fragmented process; however, there are important emerging initiatives in the field, stimulating a broad debate about the mix of approaches, agendas, and practices for S&ID. There, the field has been established at universities, research institutes, and non-governmental organizations (NGOs), with a timid presence in the private sector, media, and the broad public opinion (CILAC, 2020). It is presenting itself as a challenge to S&ID in GS, where those institutions should be capable of sensitizing a broader spectrum of stakeholders to achieve sustainable scientific and technological cooperation at the academic, private, and diplomatic sphere and beyond.

Addressing the scope of the special issue "Science Diplomacy and Sustainable Development: Perspectives from Latin America," this article aims to present an analytical typology to the study of the emerging experiences of S&ID in LA, catching the diversity of this research agenda. This is a qualitative merged method-based study, supported by a literature review, documentary research, online data analysis, and typology building.

Thus, to contribute to this research agenda internationally, this paper brings interdisciplinary theoretical and methodological approaches, suggesting that the understanding of the field of S&ID in LA can greatly benefit from a broader review of literature, and that the specificity of the regional cases can be discussed in the analytical typology proposed here.

METHODS

The paper presents the results of a qualitative-based merged method study about the emergence of initiatives and policies of S&ID in LA in different national contexts. We supported our analysis with a combination of four strategies and data collection: a literature review, documentary research, online data analysis, and the building of an analytical typology based on selected cases of institutional building in S&ID in LA. All the data collection is based on the scholarly experience of the authors in the field, as well as their involvement within two sessions of the so-called "São Paulo School of Advanced Sciences on Science and Innovation Diplomacy" (InnSciD), formerly sponsored by the São Paulo Research Foundation (FAPESP), which took place in 2019 at the campus of the University of São Paulo in the city of São Paulo, Brazil, and virtually in 2020. More details and explanation of the methodological steps are described below.

Empirical Research Design

Empirical research design (ERD) is a research strategy that improves the methodological and analytical framework using evidence of experiences and empirical validation of relevant cases (Mills et al., 2010). Due to the coronavirus disease 2019 (Covid-19) outbreak, the ERD for this paper took place virtually in Brazil, and the collection of primary and secondary data was conducted between February and June 2020. During this period, the authors were promoting webinars and e-symposiums as part of the activities of the Centre for International Negotiation Studies of the University of São Paulo's Institute of International Relations, where several PhD students, researchers, and guest speakers presented developments of their investigation and interesting emerging debates related to the field of S&ID.

Data Collection

Primary and secondary data were collected through a literature review and the documentary research, mainly in online sources, which highlighted the importance of recent initiatives of S&ID at local level and a growing agenda of international collaboration between groups in LA and EU (Sánchez, 2018). Moreover, material was selected from important non-state actors in academia, national authorities, professionals from business sectors, and people from NGOs involved in the production of reports, discussion papers, and presentations about the initiatives of S&ID in conferences and professional events internationally, in person in 2019 and virtually in 2020.

Despite focusing on the description of some patterns of the experiences in S&ID in LA, an interesting achievement of this article is the critical analysis about the role of foreign policy and its tools in bridging the gap more broadly between science and technology policies and society. Hence, the emergence of S&ID can be a response to the failure of state actors to promote better governance to solve the lack of competitiveness of knowledge-based sectors in the region. The data collection also feeds the interdisciplinary debate presented in this article on how different literatures can help to understand the incapability of governments to create and maintain a more efficient and sustainable agenda for ST&I in LA.

According to the review, all selected cases were reported in articles and editorials regarding the experiences of S&ID. Documents were scrutinized that describe emerging relevant initiatives under design and implementation in different national contexts of LA. In addition, a documentary research was conducted in the available files of the two sessions of the

InnSciD conferences in Sao-Paulo, Brazil. There, the following were found: 12 presentations of the main invited speakers, one official report of the conference, and eight abstracts of the current research of PhD students, postdoctoral researchers, guest scholars, and other partners from NGOs, academia, EU, and other international boards. The case selection is described in the section below.

Case Selection

Reviewing articles and reports and conducting documentary research in the files of the InnSciD have shown a variety of experiences of S&ID in LA. To organize the case selection, firstly, relevant actors and institutions were separated into two categories: state and non-state actors. State actors are understood here as only national cases in which the structure for S&ID is under the umbrella of the foreign policy at the national/federal level, or other initiatives exclusively centralized and managed by governmental authorities, its professionals, and internal competencies. Regarding the non-state actors, these are institutions that merge different *rationales* from other sectors of society, mainly academic-oriented groups, NGOs, and initiatives between the public and private sectors, which can involve the state, but not as a coordinator or central managers of the institutional building and development.

Finally, a number of 21 actors of institutional building in LA were selected, composed of: 12 state actors/countries (i.e., Brazil, Mexico, Bolivia, Uruguay, Cuba, Panama, Paraguay, Chile, Colombia, Costa Rica, Guatemala, and Organization of Ibero-American States OEI) and 9 non-state actors (i.e., Inter-American Network of Academy of Sciences IANAS, Latin American Academy of Sciences ACAL, Open Forum of Science in Latin America and Caribe CILAC, Bolivian Observatory of Science BOS, Uruguayan Technological Consulate in San Francisco UTCSF, Regional Leaders Summit RLS, São Paulo School of Advanced Sciences on Science and Innovation Diplomacy InnSciD, Porto Digital of Recife, and the Cuban Academy of Sciences CAS).

Coding

The main trends in S&ID in the 21 selected actors and institutions were cataloged and positioned in six different analytical categories, regarding the way they are structured in terms of their main goals and sphere of influence and governance. Finally, **Table 1** was created with a concise description of the relevant policies and initiatives promoted by those institutions in those countries. The data are collected and presented in **Table 2**.

Typology

A wide range of initiatives of S&ID in LA were envisaged regarding the level of institutionalization of the actors and policies involved. The analysis of the institutional building in LA brings a great diversity of experiences, which can be characterized as heterogenous, and in some cases spontaneous and working in a quasi-multi-level dimension, i.e., covering different levels of the state and non-state regimes of governance.

TABLE 1 | Categories of the analytical typology ($N = 6$).

	Group	Type of initiative
Non-Institutionalized initiatives	A	*ad-hoc* summits and expert panels
Under institutionalization	B	Academic-oriented projects
Institutionalized initiatives	C	Observatories and tentative regimes
	D	Agendas of non-governmental organizations
	E	Tools of Foreign Policy
	F	International organizations and supranational programs

Building a typology was a challenge, since it is not simple to organize such a complex and dynamic number of experiences in the continental level. In the typology, only those experiences in LA were selected that are focused on science diplomacy and innovation diplomacy, strictly considered. There has been excluded from the analysis the signature of agreements encompassing science and technology not yet translated into institutions, programs, courses, departments, or strategies on S&ID.

Furthermore, the typology aims to provide some introductory parameters that can be helpful to analysts to move forward with deeper and more specific studies of those experiences. The main adopted parameter is what the authors call "level of institutionalization," i.e., how far policies or initiatives went in terms of producing stable agendas of action and in creating routinization of those initiatives over the past few years; moreover, how successful it was to promote stable interconnections with other partners and policies in a multi-level and multi-sectoral perspective (from state actors to subnational entities or from the official Foreign Policy tools to the business sector, academia, or NGOs coordinated initiatives). It was built based on other selected dimensions that drive the institutional building of S&ID in the LA, from non-institutionalized subnational experiences to institutionalized actions at the national level, international collaboration, and state-driven regimes of governance.

Finally, the cases were positioned in the typology based on our understanding about the literature review on S&ID, presentations in the InnSciD SP, and author's experience on the field regarding to how the cases reflect (1) level of impact of scholarly and professional knowledge produced by actors in different national and subnational contexts, (2) level of openness and transparency of the initiatives, (3) level of participation in international collaboration, (4) level of maturity of the S&ID initiatives, and (5) reach of governance between actors in different levels (5). To elaborate this, official data were collected from the review of literature, governmental

TABLE 2 | Distribution of selected actors and institutions in the typology ($N = 21$).

Group	Name	Composed mainly by	Institution	About	Is it a state or non-state driven initiative?
A	Non-institutionalized initiatives	*ad-hoc* summits and expert panels	Cuban Academy of Sciences - CAS	The Academy of Sciences of Cuba is an official institution of the Cuban state, national, independent and consultative nature in science, continuing the Royal Academy of Medical, Physical and Natural Sciences of Havana, founded on May 19, 1861, attached to the Ministry of Science, Technology and Environment.	State
			Universidad de los Lannos in Colombia	Program in Science Diplomacy. Among the actions, started a work of identification and motivation of mutual interest between Colombian scientific diaspora to increase cooperation activities, programs and collaborative projects.	Non-state
			Institute of Foreign Service Manuel María Peralta, Puerto Rico.	Ministry of Foreign Affairs through its Institute of Foreign Service Manuel María de Peralta convened a group of notable experts in scientific and technological areas for a discussion about the relations between diplomacy and Science.	
B	Under institutionalization	Academic-oriented projects	Regional Leaders Network – RLS Network	The members of the Regional Leaders Summit are seven key regions across the world, and their strengths extend to science. There are areas where the seven members share existing competencies and excellence in science and innovation.	State/Non-state
			Open Forum of Sciences of Latin America and the Caribbean - CILAC	Open Forum of Sciences of Latin America and the Caribbean (CILAC) is an academic space for debate and exchange about science, innovation and technology.	Non-state
			Sao-Paulo School of Advanced Sciences on Science Diplomacy and Innovation Diplomacy - InnScID SP	InnSciD SP focuses on the academic and professional training of researchers, diplomats and company representatives (InvestSP, 2020) while fostering a rich network of professionals from multidisciplinary backgrounds on S&ID. Since its first edition, InnSciD SP has been evolving into a research program on the subject.	
C	Institutionalized initiatives	Observatories and tentative regimes	Bolivian Observatory of Science BOS - Extraordinary Representative on a Special Mission for Science, Technology and Innovation	Extraordinary Representative on a Special Mission for Science, Technology and Innovation with international organizations and entities in the Silicon Valley, to create the BOS.	State/Non-state
			Uruguayan Technological Consulate in San Francisco	Technological Consulate in San Francisco (USA) for the management of capacities for a better insertion on the global scenario, with the objective of creating opportunities for the national innovative ecosystem	
			Porto Digital of Recife, Brazil	The Porto Digital (Porto Digital, 2021) is a technology park and innovation organization in Brazil, currently working in the fields of Information Technology and Communication, Creative Industries and Urban Technologies. There are representatives of different boards of Ministry of Foreign Affairs, consulates, state/federal stakeholders, and other international partners.	
D	Institutionalized initiatives	Non-governmental Organizations' agendas	The Inter-American Network of Academies of Sciences - IANAS	IANAS is a regional network of Academies of Sciences and it was created with the mission of supporting cooperation to strengthen science and technology as a tool for development in the Americas	Non-state

(Continued)

TABLE 2 | Continued

Group	Name	Composed mainly by	Institution	About	Is it a state or non-state driven initiative?
			Latin America Academy of Sciences - ACAL	ACAL is one of the Academies of Sciences part of IANAS. By focusing on mathematical, physical, chemical, life, and earth sciences, it also intends to increase science cooperation in Latin America and the Caribbean	State/Non-state
E	Institutionalized initiatives	Tools of Foreign Policy	The Foreign Affairs Services, Paraguay	The Foreign Affairs Services of Paraguay declared that S&ID was incorporated into the services in order to potentialize the work of ambassadors.	State
			Diplomatic Academy of Chile Andrés Bello - ACADE	To this end, the Diplomatic Academy of Chile Andrés Bello (ACADE) created the course "Science Diplomacy Formation."	
			Science Diplomacy Strategy of Panama	Science Diplomacy Strategy created by the Ministry of Foreign Affairs of Panama and the National Secretariat of Science, Technology and Innovation	
			Innovation Diplomacy Program, Brazil	Innovation Diplomacy program deployed by the Ministry of Foreign Affairs through SECTECs, with support of the Apex-Brazil and EMBRAPII	State/Non-state
			Mexican Agency for International Development Cooperation - AMEXCID	Mexican Agency for International Development Cooperation (AMEXCID) has a partnership with the Mexican Ministry of Foreign Relations (SRE) in topics related to S&ID.	
F	Institutionalized initiatives	International Organizations and supranational programs	Organization of Ibero-American states OEI: CTS	Ibero-American Observatory of Science, Technology and Society (CTS) has the objective of strengthening the institutions of Higher Education, where the Ibero-American scientific production is mainly generated.	
			Inter-American Institute for Global Research IAI: STeP	Inter-American Institute for Global Research (IAI) is an intergovernmental body created toward S&ID, creating the IAI Science Technology & Policy (STeP) Fellowship aiming at professional development on three initial pillars of Science Diplomacy, Communication, and Leadership.	State
			Network of Science and Technology Indicators in Ibero-America - RICYT	RICYT was adopted by the CYTED Program as an Ibero-American network and by the Organization of American States (OAS) as an Inter-American network. Today, its main support is the Ibero-American States Organization (OEI), through the Observatory for Science, Technology and Society CTS	
			Ibero-American Science and Technology for Development Program - CYTED	CYTED promotes cooperation in science, technology and innovation for the development of the Ibero-American countries	
			Organization of American States OAS: COMCyT	Inter-American Committee of Science and Technology (COMCyT). Its role is to contribute to the definition and execution of OAS policy on scientific, technological and innovative partnership for development	

agencies (as Foreign Ministry's advisory boards, Secretaries of Science and Technology, academic Departments of International Relations, S&T agencies as CONICET, CNPq, CONCYTEC, etc.), other qualified information available online, or shared in the presentation and documents of the InnSciD SP 2019 and 2020. Additionally, data were gathered from reports from the EU and other international boards. A detailed explanation of the limitations of this typology is provided in the Limitations section.

RESULTS

S&ID in LA: A Field Under Construction

Mainly coordinated by official state-level actors and institutions after World War II, international collaboration in science and technology is a cultural and political phenomenon in Western societies and has been studied by different fields of humanities and social sciences over the last century. The development of the so-called S&TP occurred in parallel with the emergence of

new tools to rationalize the scientific knowledge production in democratic environments. The publication of the report "Science the Endless Frontier," written by an engineer, Vannevar Bush in 1945 and resulting in the creation of the National Science Foundation in the USA in 1950, can be considered a milestone in this process (Bush, 1945).

At the international level, LA's foreign policy played an important role in international agreements on science and technology regionally. Since the 1920's, they have a long trajectory of S&ID embedded in cultural agreements, and the so-called "cultural diplomacy" explicitly encompassed science and education as the subject of international politics. Furthermore, those agreements aimed at fostering LA countries' soft power abroad and regional integration in the search for development and economic autonomy from the major global powers (Santos, 2009; Ferreira and Oliveira, 2020).

However, we are facing an unprecedent change in the configuration of the policies for ST&I since the late twentieth century, which has been mobilizing non-state actors and civil society. It has also promoted a movement of rethinking about who should drive the translation of scientific knowledge to broader society, and what kind of political framework is better prepared to achieve this sustainability more efficiently, financially, and environmentally. These groups are now building strong geographical decentralized networking and re-designing new regimes of governance of knowledge-based enterprises, that is challenging either governments, industry, and academia at different levels of political and cultural analysis.

S&ID can be considered a result of these macro-economic transformations in the dynamics of States and ST&I, and that is why this is an ongoing process. Selleslaghs (2017) provides a description of the concept of science diplomacy as "a multi-faceted concept" focusing on "diplomacy for science in the meaning of using diplomacy or foreign policy tools to establish stronger cooperation and interaction in the area of research, innovation and higher education, which would eventually benefit one's own research, higher education and innovation capacities" (p. 3).

Leijten (2019) suggests that S&ID is a concept "still under construction," drawing attention to the fact that "innovation policies are usually closely linked to or embedded in foreign economic policy and trade policies," i.e., the private sector, and that S&ID depends on a complex interplay between economics, technology, and institutions (p. 2, 3). Likewise, the "São Paulo Framework of Innovation Diplomacy" (2019) defines the field as the set of ideas, strategies, and practices that "lies at the intersection of innovation and foreign policy," displayed by national and subnational actors, employing diplomatic processes to enhance innovation capabilities. Finally, another useful definition for S&ID is proposed by Aukes et al. (2019), that it would be characterized as a meta-governance approach itself, understood as a constellation of governance arrangements, stakeholders, and *de facto* governance practices. Then, it is an open concept that allows a diversity of approaches, being a dynamic and plastic idea.

However, S&ID did not grow symmetrically around the world. Despite the globalization discourse suggesting a "global wave" of new scientific and technological innovations in the early 2000, affecting all countries in a similar way, LA has shown that it was far from being considered a reality. The continent is historically positioned in the periphery of this global movement and significantly impacts the debate on S&ID since there it is characterized by particular fragmented regimes of knowledge production and different levels of economic performance.

The reasons for the peripheral positioning of LA in the global chains of ST&I are extremely diversified in the literature of Science, Technology and Society (STS) and have been studied by important scholars in the twentieth century, such as Amilcar Herrera and Oscar Vildavisky who delivered great scholarly achievements to Latin American thought on S&T. Recently, Hebe Vessuri, Lea Velho, and Pablo Kreimer (Kreimer, 2019) have presented important contributions about the production, use, and circulation of knowledge in LA as the object of sociological inquiry, as well as its manifestations in politics and culture. However, there is a lack of dialogue between this literature and international relations, diplomacy, geopolitics, and strategy. Hence, this paper can be considered a first step for more investigation in this direction.

There are some possible reasons for the recent development of S&ID in LA[1], in which can be highlighted: a historical strengthening of national and subnational actors in its capability to interfere in systems of knowledge production and in the diffusion of technologies and innovations beyond the traditional grasp of the official policies for ST&I, i.e., S&TP; the growth of a new sociotechnical infrastructure that has enabled scientists and investors of technology-based business to communicate more efficiently and permanently through the internet and other digital devices, and the geographical complexity of the dynamics of science and technology itself nowadays, that flows at an unprecedented speed. As other international experiences of this field, S&ID in LA can be understood as a coordinated approach and practices between different state and subnational actors around the comprehension of the governance of the global systems of ST&I. As new actors and stakeholders appear, "new infrastructure, competencies and capabilities are required as well as new governance models" (Sánchez, 2018).

A Typology for the Institutional Building of S&ID in LA

This article proposes a typology to the study of the emerging experiences on S&ID in LA, catching the diversity of this research agenda. The main objective is to identify these experiences in a bi-dimensional basis, taking into account their level of institutionalization and the nature of the main actors involved in its current governance.

Non-institutionalized Initiatives: *ad-hoc* Summits and Expert Panels

Non-institutionalized initiatives is the term used here for those that do not focus directly on S&ID itself, even though they do practices that can be fitted in the concept. This category is mainly

[1] As a matter of space and scope, since our work focuses on the presentation of an analytical typology, we will not go further on the reasons for the recent birth of S&ID in LA. For this discussion, see the concept of Latin American Thought in Science, Technology, and Development (PLACTED) in Sabato (2011).

composed of *ad-hoc* summits and expert panels on S&ID, as they have been developed by Costa Rica, Colombia, and Cuba.

Costa Rica has been promoting strategic thinking and strengthening the capacities of Costa Rican diplomats about the interplay between science and foreign policy. In August 2019, the country convened a group of notable experts in scientific and technological areas for a discussion about the relations between diplomacy and science. The effort was carried out by the Ministry of Foreign Affairs through its "Institute of Foreign Service Manuel María de Peralta" in an attempt to promote S&ID-oriented initiatives (Costa Rica, 2019).

In Colombia, the Ministry of Foreign Affairs presented a document with principles and guidelines for Colombian foreign policy to the years 2018–2022 (Colombia, 2018). The text mentions the use of diplomatic actions for Colombia to be a reference in science, education, and culture. However, science diplomacy is not addressed as a concept. Immersed in the framework of the Foreign Affairs Ministry and the Administrative Department of Science, Technology and Innovation (Colciencias), the University of Llanos started a Program in Science Diplomacy to create a network of the Colombian scientific diaspora. The aim is to increase cooperation activities, programs, and collaborative projects, in the integral development of the region (Unillaños, 2020).

On the occasion of the diplomatic opening between Cuba and the USA in 2015, Cuba's Academy of Sciences CAS and the American Association for the Advancement of Science (AAAS) played an important role paving the road for new collaborations in ST&I between both countries (Jorge-Pastrana et al., 2018). It is also noteworthy that Cuba has a long trajectory in deploying cultural diplomacy on health systems-related topics with international partners, i.e., sending physicians abroad, which can be considered a way to exchange useful knowledge around the world.

Initiatives Under Institutionalization: Academic-Oriented Projects

The "initiatives under institutionalization" are characterized by being frequently focused on academic-oriented projects toward science diplomacy and innovation diplomacy. They often not only discuss S&ID from academic grounds but also execute recommendation policy reports and memoranda about the global dynamics of ST&I addressed to inform policymaking in governments and in the private sector. Hence, three initiatives were positioned in this category: The Open Forum of Sciences of Latin America and the Caribbean (CILAC), the São Paulo School of Advanced Sciences on Innovation and Science Diplomacy (InnSciD SP), and The Regional Leaders Summit (RLS-Sciences).

CILAC is an itinerant-based academic space for discussion and exchange of knowledge about the global dynamics of scientific and technological routes. The forum is subscribed by the United Nations Educational, Scientific and Cultural Organization (UNESCO), and every 2 years, the forum promotes a face-to-face meeting addressing the debate on how to strengthen and implement effective initiatives of ST&I in line with the sustainable development goals of the Agenda 2030 (CILAC, 2020).

InnSciD SP started in 2019 as a 2-week summer school event funded by the São Paulo Research Foundation FAPESP and organized by the University of São Paulo's Institute of International Relations, with the support of the Brazilian Ministry of Foreign Affairs. One of the results of the event was the so-called São Paulo Framework Innovation Diplomacy, in which participants included their perspectives and future orientations to the field of S&ID (InnSciD SP, 2019). The event's focus is the academic and professional training of researchers, diplomats, and people from company representatives, aiming at fostering a multidisciplinary networking of researchers and professionals. In 2020, the second edition of the event was online and involved more than 15 speakers from international centers on S&ID, as well as more than 100 participants from 10 different countries, becoming a well-known experience on S&ID in LA.

Lastly, RLS-Sciences is a scientific and research network operating through a multilateral political forum of seven partner regions: Bavaria, Germany; Georgia, USA; Québec, Canada; São Paulo, Brazil; Shandong, China; Upper Austria, Austria; and Western Cape, South Africa. RLS-Sciences is designed to create a sustainable and effective framework for cooperation in ST&I between the seven regions. Even though it is not a Latin American initiative, it involves the region of São Paulo as an active member. The summit's governance consists of three levels of coordinators in each region: Political Coordinators, Scientific Coordinators, and Administrative Coordinators. These boards are partners in multilateral projects and are integrated in scientific networks between and within the regions (RLS-Network, 2020).

Institutionalized Initiatives: Observatories and Tentative Regimes

Institutionalized initiatives on S&ID in LA are divided into four groups: "observatories and tentative regimes," "agendas of non-governmental organizations," "tools of Foreign Policy," and "international organizations and supranational programs," i.e., from less to more institutionalized. Observatories and tentative regimes are more institutionalized initiatives than A and B and are innovating the landscape of the field by their focus on innovation diplomacy and, consequently, wider integration and dialogue with the private sector into their model. Three initiatives were selected in this level: the so-called Porto Digital of Recife-PE, Brazil, The Bolivian Observatory of Science BOS, and the Uruguayan Technological Consulate in San Francisco.

The Porto Digital is a deliberated public policy, created to insert Pernambuco in the technological and innovative scenario of the world. The state government funded a significant amount to implement its infrastructure, and the management of the initiative was implemented through a non-profit civil association, qualified as a Social Organization (OS) by the Government of Pernambuco and by the City of Recife (PCR): the Porto Digital Management Centre (NGPD). The activities of Porto Digital are based on the Triple Helix Model and bring together two business incubators, two business accelerators, two research institutions,

a superior education institution in ITC, and several government agencies (Porto Digital, 2021).

In a slightly different model from the current endeavors of LA countries, in 2020, the Government of Bolivia created the position of Extraordinary Representative on a Special Mission for Science, Technology and Innovation (Bolivia, 2020). Curiously, one of the representative's roles is to be based in the Silicon Valley area to facilitate the exchange between researchers, entrepreneurs, and managers for the creation of the "Bolivian Observatory of Science" and the National Fund for Science, Technology and Innovation. The model is similar to that inaugurated by Denmark, the first country to detach a Tech Ambassador to the Silicon Valley and, in some way, puts corporations on the same level as sovereign governments. As expected, it is becoming the object of critics and concern between members of traditional Foreign Policy (Feertchak, 2017).

The same movement has been followed by Uruguay: the country just opened its first Technological Consulate in San Francisco, USA, to be able to promote a better integration of Uruguayan stakeholders in the global ST&I flows, aiming to create opportunities for the National System of Innovation. It is focused on two main goals: linking technology-based companies, universities, and venture capital funds and promoting cooperation with business and local authorities in the USA and Uruguay. This new Uruguayan headquarters in San Francisco will serve as a pilot experience for the implementation of a "Diplomacy in the Digital Era" or "TechPlomacy" (Uruguay, 2020).

Institutionalized Initiatives: Agendas of NGOs

As institutionalized initiatives, there are NGOs that have designed specific agendas on S&ID, aiming at increasing scientific cooperation in respective regions and creating a network to guide scientific advice to *policy makers*.

Two regional NGOs stand out in this venture- the Inter-American Network of Academies of Sciences (IANAS) and the Latin America Academy of Sciences (ACAL). IANAS is a regional network of Academies of Sciences, and it was created with the mission of supporting cooperation to strengthen science and technology as agendas for development in the Americas (IANAS, 2020). ACAL is one of the members of the IANAS. By focusing on Mathematics, Physics, Chemistry and Life and Earth Sciences, it also intends to increase science cooperation in the Latin American and the Caribbean regions by creating a net to guide scientific advice to *policy makers*. Its main activities are the development of cooperation programs, including the dissemination of regional scientific events and the evaluation of the research potential of the region with the support of the formation of regional research networks (ACAL, 2020).

Institutionalized Initiatives: Tools of Foreign Policy

This category encompasses what we called tools of foreign policy: the initiatives for science and innovation in the official boards of diplomats, deployed by Foreign Affairs Ministries in partnership with other ministries and agencies related to science, education and technology. Here, cases were selected from Brazil, Mexico, Chile, and Panama (Panama, 2019).

Through the Ministry of Foreign Affairs, the Brazilian has a well-established public diplomacy mainly divided into two major areas: "Culture," "Education," and "Science, Technology and Innovation," with a special program focused on innovation diplomacy, the Innovation Diplomacy Program (PDI). The PDI aims at raising the profile of Brazil in relation to foreign innovation ecosystems through activities deployed by Brazilian embassies. These activities are designed around four main targets: (i) identifying partnerships and attracting investments, (ii) supporting the internationalization of Brazilian start-ups, (iii) helping to mobilize diaspora Brazilian scientific research abroad, and (iv) fostering collaboration between Brazilian and foreign technology parks and innovation environments. It is also noteworthy that the Brazilian Foreign Ministry has 54 sectors specialized in ST&I (SECTECs) in its posts abroad (embassies and consulates), in addition to the regional representative offices of the Ministry of Foreign Affairs in several Brazilian capitals. These SECTECs work to explore opportunities for cooperation and project the potential of the Brazilian system of ST&I (Brasil, 2020).

To deploy the PDI strategies, the Brazilian MRE counts on two agencies: Apex-Brasil and Embrapii—The Brazilian Trade and Investment Promotion Agency (Apex-Brasil) to promote Brazilian products and services abroad and to attract foreign investment in strategic sectors of the Brazilian economy. The Brazilian Company of Research and Industrial Innovation (EMBRAPII) is a social organization by the federal public power, which, since 2013, supports technological research institutions fostering the Brazilian industry innovation. The agency operates through intense cooperation with scientific and technological research institutions, public or private, focusing on business demands, and targeting risk sharing in the pre-competitive phase of innovation. The institution maintains a wide policy for international partnerships, with the development of PD&I for the Brazilian industry with foreign companies: to promote the internationalization of companies and advance or share knowledge between countries by means of industrial innovation.

In Mexico, S&ID became important defined targets for the federal government[2]. At the federal level, the Mexican Secretariat for External Relations (SRE) acts to unfold S&ID activities through the Institute of Mexicans Abroad (IME), the Mexican International Cooperation Agency for Development (AMEXCID), and the National Council of Science and Technology (CONACYT). On the one hand, AMEXCID is a decentralized body of the Ministry of Foreign Relations (SRE) to address issues related to International Cooperation for Development, including educational, cultural, technical and scientific, and economic efforts (Ciudad De Mexico, 2020). On the other hand, the SRE and the CONACYT created the SRE-CONACYT sector research fund to the strengthening of scientific capacities and the diffusion in the areas of knowledge that the

[2]Two reports on the subject were published: one in 2018 by Centre of International Studies Gilberto Bosques, a technical support body to the Senate, and the other in 2020 by the SRE in partnership with the Barcelona Science and Technology Diplomacy Hub (Sci-Tech DiploHub).

SRE requires. Finally, the IME works on creating a strategic network of Mexicans abroad to manage the brain circulation.

Science diplomacy has become a strategic objective in the training of future Chilean and Paraguayan diplomats. While the Diplomatic Academy of Chile Andrés Bello (ACADE) created, in 2019, the course "Science Diplomacy Formation" (Chile, 2019), the Foreign Affairs Services of Paraguay declared in May 2020 that S&ID was incorporated into the services in order to potentialize the work of ambassadors, as one of the consequences of the Covid-19 pandemic (Paraguay, 2020).

In August 2018, Panamá launched the Panamanian National Strategy on Science, Technology and Innovation. The document was created to identify simple actions in the short and medium terms to promote science diplomacy as the interaction between leaders and regional experts, on the verge of science and politics. The main goal is to use science diplomacy to meet local, regional, and global challenges. The National Strategy was created by the Foreign Affairs Ministry (MIREX) and the National Secretariat of Science, Technology and Innovation (SENACYT), with the support of the UNESCO, the American Association for the Advancement of Science (AAAS), and the Spanish Foundation for Science and Technology (FECYT).

The Panamanian strategy was built around three pillars that stem from the framework created by the Royal Society and the AAAS in 2009: science for diplomacy, diplomacy for science, and science in diplomacy. Each pillar has objectives and suggested actions to achieve the better management of science diplomacy as a tool for development and for the solution of global problems that have impacted on national societies.

Institutionalized Initiatives: International Organizations and Supranational Programs

Multiple actors and different levels of international governance are crucial to the development of efficient S&ID initiatives. International organizations are important to foster S&ID and, in LA, among the intergovernmental endeavors, there are significant agendas being built over the last few decades. International organizations have played an important role in creating networks, committees, and programs within their context to account for higher education, science, and innovation, and in this category, the Ibero-American Science and Technology for Development Program (CYTED), the Organization of Ibero-American States (OEI), the Organization of American States (OAS), and the Inter-American Institute for Global Research (IAI) were selected.

An important example of this is the Ibero-American Science and Technology for Development Program (CYTED). It was created in the early 1980's by the governments of Ibero-American countries to promote cooperation in ST&I within those countries. CYTED works through different financing instruments that mobilize Ibero-American entrepreneurs, researchers, and specialists addressing the development of science and innovation projects. With a dual structure that combines institutional and functional bodies, the program has signatory agencies of participant countries, commonly responsible for their Science Policy and their relationship with governments (Gual-Soler, 2014).

Similarly, OEI is another relevant example of institutional building in S&ID, which has been establishing important programs on science, technology, and education. One of them, the Ibero-American Observatory of Science, Technology and Society (CTS), has the objective of strengthening the institutions of higher education, where the Ibero-American scientific production is mainly generated. The observatory is aimed at obtaining evidence on the capabilities, challenges, and opportunities of the Ibero-American countries in the field of science and technology, as well as on their aptitudes for the practice of scientific research, or technological development and innovation.

Among its main activities, the Network of Science and Technology Indicators in Ibero-America (RICYT) has been implemented since 1995. Recently, RICYT was adopted by the CYTED Program as an Ibero-American network and by the Organization of American States (OAS) as an Inter-American network (RICyT, 2020). It can be affirmed that those initiatives compose a group of what we call the "Ibero-American agenda for S&ID" since the level of interconnected actions, international governance, and cultural similarities are making possible great achievements in this field.

In the hemispheric dimension of the Americas, the OAS also dived into the subject of S&ID by creating the Inter-American Committee of Science and Technology (COMCyT). Its role is to contribute to the definition and execution of OAS policy on scientific, technological, and innovative partnership for development by coordinating activities on science and technology internationally. The committee had its first meeting in 1998 and, according to the OAS website, held the last regular meeting in 2013. In November 2017, the COMCyT authorities were elected during the fifth meeting of ministers and high authorities on science and technology (V REMCYT) in Medellin, Colombia (OAS, 2021). Thus, it shows that despite there being institutionalized instruments for S&ID in the hemispheric dimension, it has not been producing dynamic results in terms of the continuous collaboration with countries in LA. The socio-economic asymmetries with countries in North America, with stronger national agendas for S&T, can be part of the explanation of this challenge.

Finally, IAI is an intergovernmental board created toward S&ID in 1992. Recently, IAI has been developing the IAI Science Technology & Policy (STeP) Fellowship through a Pilot Program 2020–2024 aiming at professional development on three initial pillars of science diplomacy, communication, and leadership. The program intends to create an Inter-American Network for shared capacity building and science-policy experiences among the fellows, host institutions, and IAI member country stakeholders. Created after the American Association for the Advancement of Science (AAAS) Science & Technology Policy Fellowship, an important Associate of the IAI, STeP aims at being the national level in LA, looking to expand new cohorts from the region (IAI, 2020).

A visual representation of previous experiences and policies provided as it follows (**Figure 1**). It illustrates how those initiatives can be localized in the proposed typology and in the

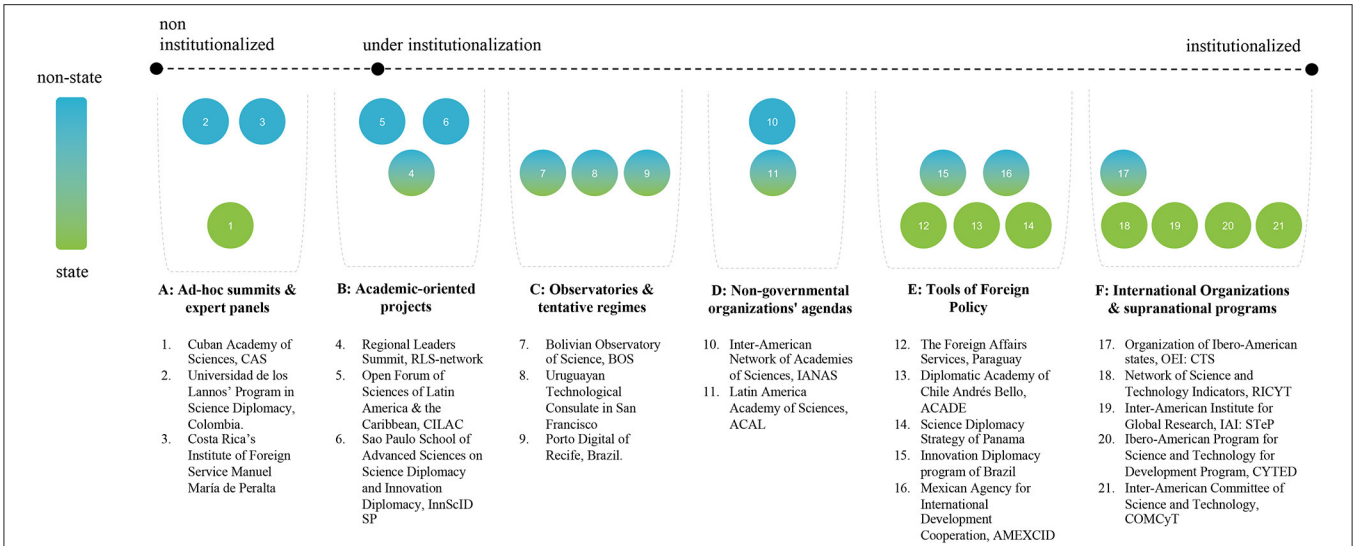

FIGURE 1 | Case levels of institutionalization and level of state to non-state involvement.

framework of institutionalization level, but there is no statistical or precise quantitative inquiry.

Limitations

Despite the presented policies and the selected cases bringing important initiatives of institutional building in S&ID in LA, the typology has some relevant limitations in terms of (1) lack or asymmetry of publications with qualified data about experiences in LA, since those are very recent initiatives, (2) information platforms/websites are still under construction, (3) initiatives of S&ID in LA continue to be analyzed mostly by researchers based in European countries, and (4) as result of all those problems, the proposed typology can only picture the characteristics of S&ID in LA with a few cases from countries with published reports/working papers.

DISCUSSION

Can Foreign Policy Bridge the Scientific and Technological Gap?

What can be seen in most Latin American countries is the absence of S&T issues on the foreign policy agenda. In reality, the themes have always been treated separately and are still largely misunderstood.

In the early 1990's, with the depolarization of the international system, the optimistic expectation that globalization could bring benefits and increase the level of cooperation between countries prevailed. However, there is no denying that the global changes, encountered in the previous decades, have imposed challenges of the most different orders to scientific diplomacy in the last few decades, since climate change, the impacts of globalization and the innovation of bureaucratic instruments. All of these elements have forced constant changes on the part of researchers, in creating new instruments and new networks that guarantee the dissemination of scientific results and the creation of new collaborations capable of breaking continental boundaries.

This context of challenges was strongly impacted by the Covid-19 pandemic and accelerated the need for dialogue between countries and for advances in cooperation agreements between scientists. However, these initiatives often run into the limitations of the governments themselves.

The COVID-19 pandemic focused attention on this issue and on others involving cooperation between states and different actors. At the international level, one of the main challenges in times of crisis is to guarantee cooperation commitments between states and to strengthen the role of international organizations. The tendency of states, especially in the face of the health crisis confronting us, is to seek to protect the population, closing borders, and implementing protectionist policies.

What gives basis to the relevance of scientific diplomacy is the identification that several conflicts could be overcome through the cooperation of scientists from different nations. Furthermore, although there is still no structured system of articulation, as in developed countries, such as the United States and the United Kingdom–examples of countries that institutionalized this system and the implementation of S&T policies as part of the list of external actions–this demand has grown significantly.

A foreign policy that could more systematically incorporate issues of ST&I, allowing the expansion of cooperation agreements with other countries and the transfer of technology, as well as the sharing of innovations in different fields, would certainly have a significant impact on developing countries in LA. However, it is noted that Latin American countries lack investment in a better articulated agenda between scientific production and the foreign policy agenda that could reduce the gap with developed countries.

Emergence of Subnational Actors

Over the last few decades, non-state actors have begun to occupy important spaces in terms of their contribution to various themes that directly affect states and individuals within the state borders. In several fields, as in ST&I, the interdependence of various actors to foster innovation and scientific advances in terms of financing, production of results, and scientific dissemination has become clear.

The institutional building in S&ID in LA is strongly related to the emergence of new subnational actors interested in the promotion of S&T, facing the decrease of dynamism and influence of traditional boards of foreign policy and of the National System of Innovation in the global arenas of ST&I. In LA, the twenty-first century is dealing with a political deficit with new approaches from the civic society, which has been led mainly by two relevant actors: the academic community based in universities and new international collaborations between NGOs, companies, and local governments.

As shown in the previous section, there are some international collaborations between local NGOs and local governments to foster S&ID that were implemented and pursued by academic-based actors (Gual-Soler, 2020). LA countries have been implementing relevant agendas of international collaboration with civic society, with an interesting level of success. Non-governmental actors and researchers have been collaborating in different initiatives promoted by the EU and other members of the business sector, which shows a strong subnational-based S&ID agenda.

Although universities, regional governments, and local municipalities do not have the legal prerogative to engage in international relations, regions have long realized that the international interface contributes to the improvement of public policies for local interests. Various cooperation agreements have been established between subnational entities creating results that are more visible to the citizens. This is true, especially when it comes to issues related to the field of innovation where the exchange of knowledge is directed to short- and mid-term policies, as well as the more effective involvement of other governmental and non-governmental actors.

In the field of S&ID, the demand from scientists and companies for greater interaction with government actors has been growing and not yet fully structured. There is still a lack of better understanding between the role of different levels of public administration in ST&I topics, both from the legal and political framework, i.e., which favors national states but also led to competition and not cooperation.

Challenges of S&ID in LA

Competitiveness in innovation systems relies on the quality of the interactions between different actors. Therefore, the existence of different actors and multi-level governance/coordination capability between them within the initiatives, whether institutionalized or not, are crucial to the development efficient S&ID and competitive innovation. However, they must be able to build coordination capability between them on a long-term basis. In LA, among the intergovernmental endeavors, there are significant initiatives from the end of the 1980's and 1990's, focusing on science and technology in the region. Yet, many of them seem to lack a strong continuity.

S&ID systems in LA are quite heterogeneous throughout the region and not sufficiently structured, denoting a lack of strategy able to improve the quality of the interactions. It is possible to identify a higher level of interconnection between some regional initiatives; however, even though there have been regional forums and institutes, more executive initiatives are often local, lacking a connectedness between different LAC actors.

In this sense, there are specific initiatives in some countries, and collaborations also by individuals or between scientific groups of academic institutions, in general universities. However, in all Latin American countries, a public policy aimed at encouraging cooperation agreements and institutionalizing collaborations is necessary to improve the articulation between foreign policy and S&ID, in order to contribute to the development of countries.

EU is pushing S&ID to LA countries at various levels, developing projects and co-operated initiatives (Selleslaghs, 2017). The EU launched the National/Regional Innovation Strategies for Smart Specialization (RIS3) under the Cohesion Policy (2014–2020) instrument (European Commission, 2013). The Smart Specialization is a policy approach with a place-based dimension, aiming at exploiting advantages of proximity to promote economic growth and competitiveness. As reported by Sánchez (2018), RIS3 (i) intends to transform regional economies around new knowledge-based activity domains (ii) through an entrepreneurial discovery process between the public and private sectors (iii) to identify the most promising activities in which to specialize (iv) within a framework of multi-faced and multi-governance interactions.

For several years, projects from different countries in LA have received support from the European Commission, through calls for tenders for scientific and innovation projects, as well as support for networks that allow the exchange of knowledge between countries with a level of development. Other developed countries have also influenced S&ID in LA: the Spanish Foundation for Science and Technology (FECYT) and the American Association for the Advancement of Science (AAAS) have been developing many initiatives in the region[3].

[3]Spain launched the INTERCOONECTA, the Knowledge Transfer, Exchange and Management Plan for the Development of Spanish Cooperation in Latin America and the Caribbean, was created with the intention of integrating, coordinating, and reinforcing the action that Spanish Cooperation develops in terms of training and knowledge for more than 25 years. In 2017, within the framework of the INTERCOONECTA Plan for Spanish Cooperation, the Spanish Foundation for Science and Technology (FECYT) and the Spanish Agency for International Development Cooperation (AECID) organized the course "Scientific Diplomacy for managers in Latin America" aimed at managers of public organizations from Latin American countries and the Caribbean region. The course happened in Santa Cruz de la Sierra, Bolivia. FECYT was also present in the design of the Panamanian National Strategy on Science, Technology and Innovation, along with AAAS and UNESCO. More information about the Science Diplomacy course at https://www.fecyt.es/es/noticia/fecyt-organiza-un-curso-de-diplomacia-cientifica-en-latinoamerica-0. Accessed in November 2020. In addition, the SciTech DiploHub, a subnational S&ID initiative from Barcelona, created an important analysis note on S&ID in partnership with Institute Matías Romero, from the Mexican Government (Roig, 2020).

Although external pressure can accelerate the establishment of S&ID and create a more homogeneous global system, it can also create policies that do not meet local needs. The active participation of local scientists and policy makers is essential to the success of S&ID in developing quality interactions within the region. Even though there are important connections with the USA and the EU and countries specifically considered, there is a lack of integration between LA countries to build an organic and strong S&ID strategy.

The various experiences of regional integration in LA could have already advanced more robust cooperation projects in the area of scientific diplomacy and innovation, but this field was never given priority. The integration processes themselves would benefit, given that a broader integration has always been chosen, especially since the 1990's, involving government actors at the head of the negotiations, but also private actors. Integration processes, such as Mercosur, had the involvement of non-governmental actors who, on many occasions, have advanced cooperation even more than the governmental agreements themselves.

As a model, taking into account policies developed by the European Union, this could in fact contribute to advancing policies that allow a better articulation of the different actors, and between public policies and the foreign policy agenda. As has been shown, there is a multitude of actors that could benefit from an efficient articulation to be effective, and the region could learn from established and profitable initiatives.

CONCLUSIONS

The paper centralizes the existence of multiple experiences of S&ID in LA, which deserves in-depth research and analysis. The main contribution here is to provide a simple typology regarding the varieties of S&ID initiatives and how its institutional building is being influenced by state and non-state actors, regionally and globally. The main finding is the necessity for better articulation between S&ID initiatives in and among LA countries, as well as a wider understanding of the dynamics of ST&I in GS countries, that brings challenges but also possibilities of open agendas. This articulation is key to integrate multiple subnational and non-state actors, addressing the improvement of the agendas of foreign policy toward more effective actions and instruments to foster the development of ST&I in the region. Consequently, it is necessary to understand S&ID as tools for social and economic development—and not an end in itself.

In this sense, the building of common ground, with shared values and goals, between those different actors and countries seems to be critical. From this understanding, it is possible to develop a strong and coherent framework outlining the short-, the medium-, and the long-term objectives and policies able to support the actions. This will influence greatly the *quality* of the interactions, orienting the results.

Many S&ID initiatives were identified in the LA region with different levels of institutionalization, involving different stakeholders and levels of governance. However, many of those initiatives seem to be fragmented and lacking steady continuity, denoting poor capacity to picture long-term agendas. This seems to be due to some limitations that are holding LA back, such as a weak S&T policy, low levels of independency of educational and scientific systems, and political instability.

The enormous potential for cooperation in S&ID between LA countries can clearly be seen, and this article can hopefully provide introductory tools for future work about this subject.

AUTHOR CONTRIBUTIONS

RS was the primary author and developed the paper proposal and it written, which includes conception, literature review, empirical design, data collection, data analysis, and the presentation of its main results and discussions. GF was responsible for data collection and analysis, writing, articulation of the parts, and the presentation of its main results and discussions. AO and JO participated actively in the written of results, discussion, and conclusion, as well as in the paper submission. All authors facilitated all levels of the documentary research and access to primary data (information about the FAPESP São Paulo Advanced School on Science and Innovation Diplomacy), as well as the construction of the database, case selection, the construction of the typology, and the discussion of results, also to providing assistance with data catalog, reviewing, and agreed with the submitted and reviewed version of the article.

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Science Diplomacy in Emerging Economies: A Phenomenological Analysis of the Colombian Case

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Little has been investigated about Science Diplomacy (SD) in emerging economies, more specifically on governance schemes useful for organizing intersecting actors, practices, conceptions and suggestions of the future in foreign affairs and Science, Technology and Innovation (STI) in public administration sectors. This paper contributes to a better understanding of the "texture and nature" of SD initiatives in emerging economies through the eyes of relevant actors involved or reflecting about them in Colombia. The aim of this paper is to propose a general governance scheme for SD in emerging economies and its potential instrumentation for a policy-mix. In Colombia, SD initiatives are very fragmented, and are not part of the priorities of the Colombian state, however the increasing interest of an embryonic practitioner and scholar community working in the topic make necessary this work. A phenomenological perspective combined with a single case study research methodology is used to gain a very accurate description of the state of the situation of SD in Colombia. Policy document review and semi-structured interviews were conducted with 18 relevant actors to understand the conceptions, practices, and suggestions for the future of SD in Colombia. The study results show that SD actors in Colombia are scattered, practices strongly related to traditional cooperation diplomatic activities and the need to give a function to SD for capacity building, better global intermediation and the development of new knowledge, in particular promoting SD abilities in the scientific community. In addition, data expresses the need to cultivate a multi-stakeholder working group for such a purpose. The study reflects on the need of a policy mix for SD in emerging economies. It proposes a general governance scheme for it, a potential instrumentation founded on research participant future suggestions, and a set of practical recommendations and policy implications. Conclusions and further research questions are set, pointing out the importance of including non-conventional diplomacy actors and knowledge, and the need to inquire rationales behind possible SD policy mixes in the southern world.

Keywords: science diplomacy, emerging economies, international cooperation, research policy, policy mix, governance

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INTRODUCTION

The interaction between science and diplomacy is becoming more and more necessary for governments to tackle global challenges. Such interaction has been defined recently as a process and a set of practices at the intersection of these two domains, what is called Science diplomacy (SD) (S4D4C, 2019). SD initiatives are mechanisms to promote and strengthen science, technology and innovation (STI) activities at the national level. In emerging economies, SD has been the basis for the generation of research centers, bilateral projects, mobility programs for scientists, and capacity building actions in STI. In Latin America, the approaches to SD are diverse. Panama, for example, developed in 2018 a SD policy with the leadership of the Ministry of Foreign Affairs. Other countries in the region such as Brazil, Mexico, and Cuba have also implemented their own strategies.

Most of the literature that delves into the concept of SD in emerging economies has a focus on specific instruments to promote STI cooperation (Hornsby and Parshotam, 2018), case studies focused on areas and dynamics of collaboration (Frech et al., 2018), capacity-building recommendations for individuals involved in SD (Krasnyak, 2020), and analysis of bi-regional agreements (Cherry and Du Toit, 2018). In Colombia SD initiatives are scattered, there is no state's strategy for it, and there exists a lack of coordination between relevant actors involved in such initiatives. On the one hand, inside the Ministry of Foreign Affairs there is an absence of SD discourse, and on the other hand, in the Science, Technology and Innovation Ministry there is lack of long-term initiatives of SD. However, due to (i) the peace agreement signed in 2016; (ii) the creation of the STI Ministry; (iii) the increasing interest of the government in promoting innovation as the country's engine for sustainable development; (iv) the coronavirus pandemic's public health crisis, among other reasons; there is a valuable opportunity for Science Diplomacy, especially since the efforts and coordination actions between the countries and the scientific advice required in sustainable development challenges have been essential to face the current global crisis (Vargas Solorzano, 2020). Bluntly put, there is a unique opportunity for setting SD in the country's policy agenda.

In order to analyze the existing literature, four categories were determined. According to the research objectives of the present study: (i) actors, (ii) practices, (iii) conceptions, and (iv) suggestions for the future of SD in emerging economies. There are a number of references in SD in emerging economies literature that point out to non-traditional actors of diplomacy (Pantović and Michelini, 2018, Hornsby and Parshotam, 2018, Ezekiel, 2020). Practices mentioned mostly draw to the broader dynamics of governmental support to STI collaboration (Patman and Davis, 2017; Thompson, 2018; Ezekiel, 2020) however the purpose of such practices refers to: promotion, influence and access (Flink and Schreiterer, 2010). When reviewing conceptions category, the literature on SD in emerging economies is mainly focused on *access,* this is, the development of capacities and exchange of resources in order to be part of the global scene of STI (Hornsby and Parshotam, 2018; Thompson, 2018). Regarding suggestions category for SD in emerging economies we found three main issues, (i) the need for scientists to assume leading roles in political debates, advising policy makers with scientific results and data (Patman and Davis, 2017); (ii) Foreign policy requires the integration of scientific evidence in their work to be able to support the implementation of SD initiatives (Ramírez-Cabrales and Rueda Forero, 2020); (iii) the need to identify spaces for dialogue between academics, researchers, and decision makers, in order to articulate projects to solve global issues and to address foreign policy priorities (Pantović and Michelini, 2018); as well as (iv) the need of new models of SD, including diverse actors to generate exchange and new knowledge (Thompson, 2018).

There is an important scholarship on SD in emerging economies that has been developed in Sub-Saharan Africa, Latin America, Russia, the Balkans, among others. However, the reviewed cases on Russia, India, and Brazil, are key. The Russian case shows how the Cold War, and the accession to Crimea resulted affecting the STI dynamics of the country (Ibragimova and Barabanov, 2018) and how the country nowadays, recognizes the importance of SD for tackling these issues (Krasnyak, 2020). For example, most recent actions in the country have been focused on the attraction and retention of Russian researchers (Ibragimova and Barabanov, 2018) which can restore the international image of Russian research system (Ruffini, 2017). In India, SD policy is focused in the importance of the acquisition, exchange and development of technologies through strategic alliances (Sikka, 2017), as well as the relevance to support other emerging economies through SD initiatives such as scholarships awarded to foreign scientists and experts under the Indian Technical and Economic Cooperation Program (Arunachalam et al., 2017). In the Brazilian case, the strategic approach within the South-South cooperation schemes is paramount. The concept of SD was first adopted and developed by the Ministry of External Affairs (Itamaraty), by creating the National Program on Innovation Diplomacy that is focused on acquiring a new productive-technological profile to allow Brazil to redefine its international positioning and insertion in the global economy (Anunciato and dos Santos, 2020). As it can be seen the evolution of SD in emerging economies is very dependent on the specific historical and socio-economic conditions of each country or region.

Nevertheless, there is not enough developed work about the governance of SD in emerging economies, particularly in Latin American countries. In Latin America, while many of the countries share similar historic and cultural traits, the evolution and integration of SD as a concept within the discourse of national STI and foreign policies is quite varied. There are countries in the region that are still in the very early stages of defining a strategic approach about it and still struggle to gain the necessary momentum to reach a national agreement and commitment in SD, as is the case of Colombia, the case presented in this study. For this reasons, and given the importance of reaching a common ground to foster a regional dialogue that can enable a successful interaction with other regions of the world, especially to solve common global challenges, this paper addresses the very nature of SD through the eyes of the actors involved in the incipient Colombian SD initiatives, in order

to contribute to the understanding of the intersection between STI and foreign policy and potential governance schemes in the southern world.

This study is developed under a phenomenological qualitative design and is also a case study. The phenomenological approach was chosen for this research, as it aims to understand the nature of SD as a phenomenon in emerging economies through the common experiences that different individuals have (Creswell, 2007), in order to develop (if any) a better governance at the intersection of STI and foreign policies in the southern world. The analysis was carried out through the inquiry of transcript semi-structured interviews conducted with actors involved in SD dynamics in Colombia to gain a better understanding of conceptions, practices, and suggestions for the future of SD.

In this paper, we present (i) a brief conceptual positioning regarding SD in emerging economies; (ii) the literature review tracking actors, practices, conceptions and suggestions, and a some key cases of SD in emerging economies; (iii) the general context of foreign and STI policy of the Colombian case and a vis-a-vis analysis of the international dimension of STI policy vs. the STI dimension of foreign policy in Colombia; (iv) the description of the undertaken methodology, this is the qualitative phenomenological case study approach for conducting analysis of SD in emerging economies; (v) the results of the analyses drawing from the SD actors, practices, conceptions and suggestions; (vi) a discussion around the type of governance and policy implications based on the actors' views and recommendations. Finally, (vii) the study concludes by suggesting the need of a policy mix for SD, proposing a potential general scheme and instrumentations for it in emerging economies. In addition, (viii) a set of practical recommendations and policy implications are proposed, and (ix) conclusions and further research questions are exposed, pointing out the importance of including non-conventional diplomacy actors and knowledge, and the need to inquire rationales behind possible SD policy mixes in the southern world.

The paper aims to contribute paving the way for emerging economies, and in particular for Latin American countries. The results show that SD actors in Colombia are scattered in a broad range of social sectors. From the government sector, academia, industry, civil society, individuals, international organizations, even indigenous communities, and NGOs. In terms of SD practices, the study recognizes that actor's actions are strongly related to the traditional diplomatic role of facilitating, bridging and connecting; and as a most frequent conception of SD, the participants consider, in line with the last point, that the main function of SD is "building bridges and connections." Additionally, participants' suggestions about the promises of SD in emerging economies is related to capacity building, intermediation and the development of knowledge and skills, especially promoting scientists and other actors' training on SD. Besides, the research participants expressed the need to have a multi-stakeholder working group for such a purpose. This paper helps to better understand SD in a country that is in an early stage of converging STI development and foreign affairs. A governance scheme for SD in emerging economies is proposed as inspiration for potential policy mix instrumentation (Flanagan et al., 2011; Rogge and Reichardt, 2016).

CONCEPTUAL POSITIONING

According to The Royal Society (2010) there are three dimensions for SD: (i) Science in diplomacy; (ii) Diplomacy for science; and (iii) Science for diplomacy. In general terms, they refer to the interplay between STI, international cooperation and policy. Flink and Schreiterer (2010) identify three goals at this interplay when countries devote efforts and resources to SD: countries are looking for (i) *Access* to resources (researchers, infrastructure/facilities, natural resources), (ii) the *promotion* of a country's achievements in R&D and other national assets, and (iii) *Influence* on the public opinion and decision-makers. In addition, and beyond the aspirational aim of governing sociotechnical systems for sustainability transitions (Smith and Stirling, 2006; Borrás and Edler, 2020), arguably nowadays, the globe is in the midst of an uncertain disruptive period that unavoidably implies a hard or smooth transition. In this context, SD could help to address global challenges derived from such a situation, and support the implementation of agendas tackling global as much as local priorities converging (Gluckman et al., 2017). This would be especially useful in late industrializing countries with high inequality rates (Rennkamp, 2011) as Colombia, which is characterized by less scientific human capital and technological resources that tend to be located in the Global North. Establishing meaningful alliances between governments such priorities that affect more vulnerable populations and ecosystems in these countries, can be addressed.

Having this in mind, the conceptual positioning of this paper, to propose a governance scheme for SD in emerging economies, lays out a policy mix approach. According to Flanagan et al. (2011) the common use of innovation policy mix notion can provide a reconsideration in how to better deal with complex, multi-level, multi-actor realities taking advantage of the interaction between policy instruments. Rogge and Reichardt (2013, 2016) giving one step beyond, recently stated that policy mixes refer to the combination of a policy strategy with multiple interacting instruments tackling a bunch of intimately related problems. Therefore, SD in and for emerging economies will be understood as a public arena where foreign and innovation policy instruments interact in order to address local challenges with a global scope, regularly ambitioning sustainability issues, given the disruptive context the world faces today. Furthermore, the policy mix notion framed by foreign affairs and STI issues may propose a complex governance scheme between these two domains, each time policy instruments have the power to structure the grammar of power and balances between governmental and non-governmental actors. In other words, that the potential instruments interacting in these two domains under "the umbrella" of a "unique" policy strategy are part of processes, dynamics, and designs of governance (Voß, 2007). Hence, SD, its "essence" and effects will be understood under the light of this perspective.

In general terms, SD can take many forms. However, more particularly in emerging economies, we consider it is featured by the conscious joint work of various actors, levels, mixes of policy instruments, and strategies in the interstice of foreign affairs and science, technology and innovation that can help to solve wicked problems derived from the current crisis that affect more southern countries, such as biodiversity loss or climate change.

SD IN EMERGING ECONOMIES: LITERATURE REVIEW AND MAJOR PLAYERS

Among the literature of SD in emerging economies, case studies and experiences from Sub-Saharan Africa, Latin America, Russia, Serbia, among others are found. Most of the literature that delves into the concept of SD in emerging economies has a focus on specific instruments to promote STI cooperation (Hornsby and Parshotam, 2018), case studies focused on areas and dynamics of collaboration (Frech et al., 2018), capacity-building recommendations for individuals involved in SD (Krasnyak, 2020) and analysis of bi-regional agreements (Cherry and Du Toit, 2018). The literature on SD in emerging economies found to be relevant for the purpose of this study is summarized and presented in **Table 1**.

In order to analyze the existing literature, four categories were determined, according to the research objectives of the present study: (i) actors, (ii) practices, (iii) conceptions, and (iv) suggestions for the future of SD in emerging economies, as these are cross-cutting categories that shed a light into the specific understanding and construction of the concept in the inquired context.

In addition, there are three major players that can depict the current trends of the concept in the Global South:

Russia: The development of SD in Russia was greatly impacted by the Cold War, which resulted in a "brain drain" phenomenon that reduced the number of researchers in the country, a considerable reduction of the government funding of STI activities, as well as the sanctions that were put in place after the accession of Crimea to Russia (Ibragimova and Barabanov, 2018). To the present, Russia recognizes the importance of SD and the need to integrate it within the country's foreign policy (Krasnyak, 2020). The most recent actions have been focused on restoring the international image of Russian research (Ruffini, 2017) developing a system of ongoing training and knowledge exchange in the field of scientific cooperation, in order to attract and retain Russian researchers and to provide better conditions for young professionals in STI fields (Ibragimova and Barabanov, 2018). The English-written literature does not mention any kind of governance structure or coordination among the multiple state actors that have a role in Russian SD such as the Federal Government, the Russian Academy of Sciences, the federal authorities, among others.

India: To promote SD, India highlights in its STI Policy the need to develop and achieve levels of global competitiveness through international collaborations, both bilateral as well as multilateral. This policy also reveals the importance of the acquisition, exchange and development of technologies through strategic alliances (Sikka, 2017). The main current

TABLE 1 | References in literature of SD in emerging economies.

Dimensions	Leverage points in literature of SD for emerging economies
Actors	There are multiple references in the literature to non-traditional actors of diplomacy, also referred to as Track II Diplomacy. The actors of SD are diverse: Scientists, civil society, universities (Hornsby and Parshotam, 2018; Pantović and Michelini, 2018), as well as private entities, companies, and research centers (Ezekiel, 2020). Authors also mention hybrid collectives such as epistemic communities (Hornsby and Parshotam, 2018). However, actors belonging to the Track I Diplomacy or Official Diplomacy are also highlighted: Government officials, diplomatic corps and multilateral organizations (Ezekiel, 2020).
Practices	Practices mentioned in the literature refer mostly to the broader dynamics of governmental support to STI collaboration, however their purpose refers to the three goals proposed by Flink and Schreiterer (2010): Access, Promotion, and Influence. Practices include the establishment of alliances for international scientific cooperation, which can also support countries with tense relations (Patman and Davis, 2017). SD also refers to actions supported by governments to form international alliances for human development, the creation of facilities such as laboratories to support research, projects and platforms for inter-institutional collaboration and training of researchers, in order to achieve the interests of countries in STI (Ezekiel, 2020). SD practices include those that allow the insertion of developing countries in the knowledge economy and the management of resources for the development of solutions adapted to the contexts of emerging economies (Thompson, 2018). Fostering international alliances that bring countries from the Global North and South closer together and soften the relationship between countries with tense diplomatic relations (Patman and Davis, 2017).
Conceptions	When reviewing the dimension of conceptions, SD in emerging economies is mainly focused on *access*: development of capacities and exchange of resources in order to be part of the global scene of STI. For these countries, access to developments resulting from scientific research is not always available; also obtaining resources for their own developments that can support the search for solutions to diseases, problems and challenges is usually very difficult since these resources are not available (Thompson, 2018). SD also supports the economic development of emerging economies by inserting them into global value chains and mobilizing international experiences in order to build scientific and technical capacities of interest to the country (Hornsby and Parshotam, 2018).
Suggestions for the future of SD in developing countries	Suggestions for SD in emerging economies found in the literature include the need for scientists to assume leading roles in political debates, advising policy makers with scientific results and data (Patman and Davis, 2017). Foreign policy requires the integration of scientific evidence in their work to be able to support the implementation of SD initiatives (Ramírez-Cabrales and Rueda Forero, 2020). Suggestions also include the need to identify spaces for dialogue between academics, researchers and decision makers, in order to articulate projects to solve global issues and to address foreign policy priorities (Pantović and Michelini, 2018). Thompson (2018) argues that new models of SD, including diverse, non-traditional actors of diplomacy are needed to generate exchange and new knowledge.

approaches to SD in India are related to capacity building in science and technology, development of human talent, exchange and transfer of knowledge and the development of its institutions for science, technology and innovation. This is closely related to India's approach to supporting other developing countries, for example through SD initiatives such as scholarships awarded to foreign scientists and experts under the Indian Technical and Economic Cooperation Program (Arunachalam et al., 2017).

Brazil: As a major player in Latin America's Science, Technology, and Innovation landscape, Brazil has assumed a strategic approach as a leader within the South-South cooperation schemes. In this sense, the country's approach is to position itself as a powerful player in the Global South, becoming one of the strongest voices of emerging economies around the world and an important representation of the Latin American region. In Brazil, the concept of SD was first adopted and developed by the Ministry of External Affairs (Itamaraty), which decided to move away from the concept of SD to focus on Innovation Diplomacy, by creating the National Program on Innovation Diplomacy, thus putting a strong focus on the importance of STI in the socio-economic development and on Brazil's transformation toward a knowledge economy. In this sense, the national strategy of Innovation Diplomacy is focused on acquiring a new productive-technological profile to allow Brazil to redefine its international positioning and insertion in the global economy (Anunciato and dos Santos, 2020).

As it can be seen from the review above, the evolution of SD in emerging economies is very dependent on the specific historical and socio-economic conditions of each country or region; nevertheless, there are common leverage points among them as was presented in **Table 1**.

There is a gap and a need to discuss further the governance dimension of SD in emerging economies, particularly in the case of Latin America. The case of Brazil has been partially documented in scientific publications, mostly in Portuguese, but it is one of the few cases in which the governance of SD is analyzed by using a systemic approach (Anunciato and dos Santos, 2020). However, Brazil's Innovation Diplomacy national strategy has the characteristics of a top-down approach.

In Latin America, while many of the countries share similar historic and cultural traits, the evolution and integration of SD as a concept within the discourse of national STI and foreign policies is quite varied. Even though there is not enough academic literature that documents the cases of Mexico, Argentina, Chile, Cuba, Panamá, among others, a regional trend willing to promote and institutionalize SD is evident (Gual Soler, 2020). On the other hand, there are countries in the region that are still in the very early stages of defining a strategic approach and still struggle to gain the necessary momentum to reach a national agreement and commitment in this area, as is the case of Colombia, the case presented in this study. The UNESCO's policy brief on SD in Latin America and the Caribbean carried out by Gual Soler (2020) also refers to a set of challenges and opportunities from a regional perspective that are useful for thinking about the future of SD, especially in countries that are in the process of defining an initial roadmap. Among the challenges presented, the following are highlighted given their relevance for the present study: (1) The coordination and collaboration between institutions, actors, policies and functions at the intersection between science and foreign policy; (2) The fragmentation and multiplicity of high-level fora that currently exist; (3) The fluidity of the concept and the need to find a common ground; (3) The lack of institutionalization of SD, thus leaving actions disarticulated and without continuity; (4) The need to define the skills and knowledge required and promote capacity-building in this non-traditional field (Gual Soler, 2020).

Given the importance of reaching a common ground to foster a regional dialogue that can enable a successful interaction with other regions of the world, especially to solve common global challenges, there is a risk in having such a disparity in the evolution and understanding of the role of SD in Latin America. Therefore, while taking into account successful cases in different emerging economies, by studying the case of Colombia, this work intends to contribute paving the way for this country and other countries in the region that are also in the early stages of introducing the concept of SD within their science and foreign policy framework.

Moreover, the geopolitical relevance of Colombia due to its bi-oceanic condition, its global importance as a major source of the world's biodiversity and the fact of having put an end to one of the most devastating armed conflict of the western hemisphere in present times, makes it a case worth analyzing in the context of SD in emerging economies, which may contribute to tackling global challenges such as climate change or international security.

THE INTERNATIONAL DIMENSION OF STI POLICY AND THE STI DIMENSION OF FOREIGN POLICY IN COLOMBIA

On one hand, STI processes in Colombia have had a slow and interrupted development. Even today, the expected investment in STI activities has not been achieved, and the figures are not encouraging compared to other countries in the region. Colombia currently invests an average of 0.29% of GDP in R&D, which places it well below the average for OECD countries (2.35%) and also below the 0.73% average investment of Latin American countries (OECD, 2020). The international dimension of STI in Colombia indicates a low insertion of Colombian research in international scientific networks, given an absence of strong and long-term cooperation and coordination mechanisms and a lack of integrated actions to guarantee a strategic approach to STI internationalization that involves multiple stakeholders, including the scientific diaspora (Hernández et al., 2003; Misión de Sabios, 2019). According to the Cooperation Presidential Agency (APC), STI only mobilized 0,14% of international cooperation resources in 2019 and the country is still not playing an important role as an international cooperation provider in the South-South cooperation scheme (APC, 2019). These difficulties are the result of a lack of institutionalization and coordination to allow the development of strong international

linkages and justify the need to define a SD strategy for the country (Misión de Sabios, 2019).

On the other hand, according to Amaya (2017) a historical analysis of the country's foreign policy has identified, among others, the following challenges: a predominance of short-term initiatives, a low capacity of the Ministry of Foreign Affairs to centralize the multiple dimensions of Colombia's international relations, institutional fragmentation, the rise of parallel diplomacies, discretion in the decision-making process, as well as a lack of spaces for debate with other actors. These institutional challenges, combined with the lack of prioritization of STI within the country's foreign relations agenda, result in the absence of a SD strategy in the country.

As in many other emerging economies, there are ongoing SD practices that have played an important role for the development of the STI system, especially through international cooperation initiatives promoted by governments and international organizations.

A series of isolated initiatives and examples (García, 2016; Bonilla, 2017) may prove that both Colciencias (now the Ministry of STI) and the Ministry of Foreign Affairs have contributed to support the internationalization of Colombian STI. Among those initiatives, the following two are some of the most illustrative examples of SD actions: (1) Red Caldas was a network of Colombian scientists, created and funded by COLCIENCIAS with occasional support from the Ministry of Foreign Affairs, to promote formal and informal linkages with Colombian researchers living abroad that functioned in the 1990s but failed to continue after the support from the government ended (Pellegrino, 2001); (2) the institutionalization of the honorary consuls through the 1538 decree of 2004, whose functions included, among others, the support of STI linkages with the host country. According to Isaza (2020), from this point on, high-level joint commissions have included delegates from different sectors, where some of the most important international agreements are reached. Their impact is, however, still difficult to grasp due to the challenges explained above.

The role played by Colciencias has been key for the implementation of SD initiatives in the country. For many years, the Head of the institution with the support of the internationalization unit of this Department represented the country in international high-level fora on STI, and developed specific financing instruments with matching funds negotiated through bilateral or multilateral agreements. However, constant changes in personnel and the lack of resources are a permanent concern in the organization (Plata, 2013). On the other hand, even though the country has led and been actively involved in several SD initiatives, there is no explicit intention from the Ministry of Foreign Affairs, to promote and support the design and implementation of a national SD strategy.

Nevertheless, what is described above, a series of recent milestones set now a proper scenario for a discussion on a more strategic approach to SD in the country:

1. The creation of the Ministry of STI in January 2019.
2. An official scientific mission called "Misión de Sabios" carried out in 2019. The report produced by the Mission includes a set of policy and instrument recommendations for strengthening the STI system in the long-term (Misión de Sabios, 2019).
3. The development of a new National Policy for Science, Technology and Innovation 2021–2030 expected to be launched in 2021, which integrates the recommendations from the Misión de Sabios report (Departamento Nacional de Planeación, 2020).
4. A diversification in Colombia's international agenda after the peace agreement was signed during the Presidency of Juan Manuel Santos. There is an evident search for a positive insertion through a high-profile presence in international fora, the return to multilateralism, the promotion of South-South cooperation, and the increasing role of paradiplomacy (Ardila and Clemente, 2019). The principles and guidelines of Colombia's Foreign Policy include the active promotion of a "diplomacy for sustainable development" and the support for other sectors to transform Colombia into an international attraction pole for education and STI (Ministerio de Relaciones Exteriores, 2018).

In this context, this analysis seeks to understand what kind of governance is needed and expected by the actors of SD in Colombia, by identifying and presenting conceptions, actors, practices and suggestions found at the intersection of science and foreign policy in Colombia. With this input, the aim is to suggest a series of elements that may contribute to a comprehensive policy and strategy on SD in the country for the advancement of STI and the country's sustainable development agenda, which may be adapted and extrapolated to other emerging economies.

In order to propose a SD governance scheme for Colombia, which may shed a light for other emerging economies; it is important to identify the essential elements at the intersection of STI and foreign policy. Thus, **Table 2** presents the main elements found in policy documents that can be placed at this intersection, in order to complement the analysis of the findings and categorizations resulting from the interviewees' contributions. The aim is to provide a simple overview that could be used to enable a policy mix, a strategy intersecting foreign affairs and STI development, as well as a package of instruments with well-deliberated goals (Rogge and Reichardt, 2013, 2016).

In conclusion, the overview of STI and foreign policy in Colombia presented above indicates the need for a coordinated SD strategy. Moreover, the recent developments, milestones and explicit as well as implicit elements found at the intersection of these two systems as identified in the policy documents analyzed, are enough reasons to argue that the conditions are set for a more strategic approach to SD in Colombia.

METHODOLOGY

Research Objectives

With this research, we aim to understand from an exploratory perspective, the phenomenon of SD in emerging economies, taking into account the case of SD in Colombia, in order to propose a general governance scheme for SD in emerging economies at early stages regarding the topic. For this, we analyze the conceptions, practices, actors and suggestions for the future

TABLE 2 | The international dimension in STI Policy and the STI dimension in Foreign Policy in Colombia.

The international dimension in STI Policy	The STI dimension in Foreign Policy
Statements from the Misión de Sabios (2019): • Through coordination and cooperation from the State, the strengthening and support of the scientific diaspora and the organized scientific networks of expatriates can become a platform to build trust between actors. • SD shall enable new paths for researchers and research processes from Colombia to the global research and innovation arena while contributing to the country's specificities and solving territorial needs. • The creation of specialized missions and diplomatic positions in several countries is recommended. Recommendations included in the National STI Policy (Departamento Nacional de Planeación, 2020): • Development of scientific-technical international cooperation agendas with counterparts to promote: Mobility of researchers, technology transfer, joint projects. • Increase the capacity of STI strategic intelligence and information to use scientific evidence for public policy. Development of a national prospective program with an emphasis in the 2030 Agenda. • Mobilization of international resources for STI. • Promote mission-oriented innovations. SD must be seen as a tool to implement global solutions and promote economic development and quality by inserting Colombia in international scenarios.	Statements from the Principles and Guidelines for Colombia's Foreign Policy 2018–2022 (Ministerio de Relaciones Exteriores, 2018): The 2022 vision presents Colombia as a leader through an innovative participation to provide answers to global challenges, and through actions to make Colombia a cultural, educational and tourism referent, as well as in matters of sustainability, entrepreneurship, and STI. • Development of an active "Sustainable Development Diplomacy" to achieve a better use of its natural resources, to protect and use its biodiversity and to tackle climate change effects (First action). • Foreign policy will contribute to the efforts of other sectors to transform Colombia into an international attraction pole for education, innovation, science and technology, boosting the country's capacities and generating incentives for the establishment of research centers and large joint projects. • A comprehensive, multi-dimensional policy of seas and oceans. • A comprehensive migratory policy and law that promotes labor, scientific and academic mobility (Fourth action).

of SD in emerging economies, from the perspectives of SD actors in Colombia.

Categories for Analysis

The categories of analysis were determined by prioritizing the importance of actors and actions (practices) for innovation policy mixes (Flanagan et al., 2011). The categories of conceptions and suggestions for the advancement of SD in emerging economies were taken into account, as these are cross-cutting themes that require further exploration.

Design: Qualitative Phenomenological Case Study

This study has a phenomenological qualitative design and is also a case study. The phenomenological approach was chosen for this research, as it aims to understand the common experiences that different individuals involved in SD activities or initiatives have (Creswell, 2007) in order to develop a general model of a governance scheme pointing out the importance of a package of potential policy instruments at the intersection of foreign and STI policy. It is also a singular case study, as it seeks to investigate the phenomenon within a delimited context (Yin, 2003); in this case the Colombian experience of SD. According to Creswell (2007), the case study must identify a representative case, which can be used to generalize in similar contexts.

Participants

The participants in this study were 18 actors involved in SD activities from the STI and diplomacy sectors in Colombia (see **Appendix**). Individuals coming from academia, government, scientific networks, associations, companies, and the Colombian scientific diaspora were interviewed. The participants were chosen, considering one or more of the following criteria:

- Years of experience in the fields of STI or diplomacy
- Knowledge of and interest in SD as an object of study
- Experience as part of SD initiatives or practices
- Representation of different regions of the country
- Representation of different sectors considered stakeholders of SD

Data Collection

The data collection process was carried out during September 2020, through open-ended, semi-structured interviews. The interviews were conducted virtually and recorded with the consent of the participants. The interview guide had three dimensions related to the research objectives as follows:

- Dimension 1: Questions were asked about the actors' conceptions of SD, as well as about SD actors in Colombia.
- Dimension 2: Information was required on actions and practices carried out by the system actors related to SD.
- Dimension 3: The future outlook for SD in Colombia was explored.

Data Analysis

Interview data were collected and recorded. The interviews were then transcribed. Under the methodology of qualitative content analysis and based on the information collected, inductive subcategories (codes) were created from the categories of analysis previously generated for this research. The creation of a taxonomy of categories, at the center of every content analysis, guarantees the addressing of the research question (Mayring,

2000). The qualitative analysis process was carried out with the support of the MAXQDA software, creating semantic networks.

The steps of the analysis process are described as follows:

- Codes were generated based on statements of interest for the objectives of research, using the MAXQDA software.
- After creating the codes, these were joined to the initial categories of analysis (conceptions, actors, practices and suggestions), generating semantic networks with MAXQDA.
- Since this is a qualitative study, quotations from the transcripts were chosen from the interviews, in order to present the results in a clearer way with examples.

RESULTS

The results are presented based on the four categories of analysis:, actors, practices, conceptions and suggestions for the future of SD in emerging countries.

SD Actors

The SD actors (See **Figure 1**) range from the government sector, academia, industry, civil society, and individuals to international organizations. Among the government representatives, the Ministry of Foreign Affairs, through its diplomatic missions, and international cooperation, cultural affairs, and economic, social and environmental affairs stand out. The role of the Ministry of Science, Technology and Innovation is highlighted, as well as other government entities, such as the Ministry of Education and other ministries, the Presidency and Vice Presidency, the Department of National Planning and the Presidential Agency for Cooperation (APC). Interestingly, subnational authorities such as regional and local governments are also mentioned, a statement with strong relevance in centralized but culturally diverse countries like Colombia and other emerging economies.

Within the academic sector, interviewees mentioned higher education institutions, research centers, academic and scientific associations and networks, and academies of science. The industry was also indicated by multiple interviewees as a relevant actor, considering their role in promoting innovation and technology development activities. Among the industry, research and development centers attached to companies were mentioned and multinational corporations and industry associations. International organizations such as academic and scientific associations like the German Academic Exchange Service (DAAD), the German Research Foundation, Fulbright or the British Council were identified as actors but also as an important source for the definition of a strategy, given their role and the experience they have undergone in their own countries. Multilateral organizations, such as the UN or the OECD were also mentioned as relevant actors to promote SD initiatives in the country.

Many actors from the civil society were mentioned by the interviewees, such as NGOs, science journalists, indigenous communities, scientific diaspora, and other organized groups coming from multiple backgrounds and roles but gathered around a common interest. The latter were referred to as epistemic communities (Knorr-Cetina, 1981, 1999). For the case of emerging economies, especially in Latin America, both the scientific diaspora and the indigenous communities are two actors that should be further explored and integrated into the SD discourse of these countries. On the one hand, the interviewees indicated that the scientific diaspora should be at the center of a SD national strategy, given their ability to build international links and to understand different cultures. On the other hand, indigenous communities and the role of ancestral knowledge in SD aligns with the Government's effort, especially of the Ministry of STI, in giving a place and promoting all kinds of knowledge to acknowledge the diversity of the country and its multiple worldviews.

Excerpts from interviews regarding the actors of SD in Colombia:

- *National entities such as the Presidency, the Foreign Ministry, and, depending on the sector, should involve other ministries [. . .] We also have the networks, the STI observatory, and the STI network attached to the Ministry of Science, Technology, and Innovation. In addition to sectorizing it, it is essential to lower it to regions. An international cooperation office was created in the Atlántico region. These offices must assume that role. The universities and multinational companies work with different countries and have the cultural knowledge and are interested in innovation (Participants 3).*
- *SD is a cross-cutting theme: Higher education institutions should participate; from the government point of view: Foreign Ministry, Ministry of Science, Technology, and Innovation, the Presidential Agency for Cooperation (APC), Ministry of Education and research centers. At the regional level, the governorates, mayors and secretaries of education and STI, and the secretaries of economic development (Participant 5).*
- *We have to recognize the value of our indigenous communities. Scientists are very interested in knowing and understanding the world of our indigenous peoples. Traditional, spiritual knowledge, the deep knowledge of nature, our pre-Hispanic knowledge. Indigenous peoples have their own form of diplomacy with the world outside their community (Participant 18).*

SD Practices

The SD practices (See **Figure 2**) identified by the actors in Colombia are divided into three groups:

i) Capacity building and skills,
ii) Resources for science, technology, and innovation,
iii) Bridges and collaborations.

In the category of capacity building and skills, participants identified the need to develop knowledge and skills for connecting science and foreign policy. In the second category called "Resources for STI," practices such as the mobility of researchers abroad, research and innovation projects, knowledge and technology transfer and capacity building projects in STI are identified. Within the category "bridges and collaborations," there are multiple sub-categories, including collaborations oriented toward the Sustainable Development Goals, cooperation

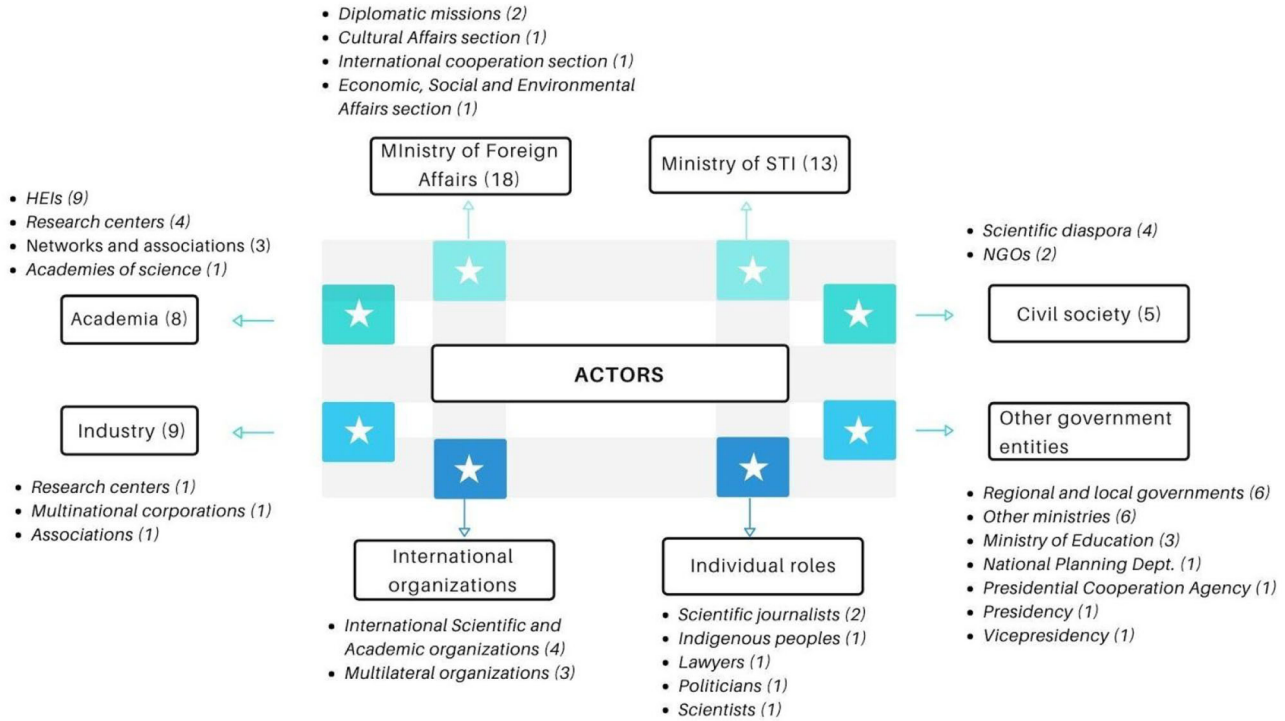

FIGURE 1 | SD Actors in Colombia. Participants were asked to indicate the actors that should be considered within a SD strategy in Colombia. Categories are developed by the authors based on the type of actors (public, private, type of organization), as well as on frequency and similarity between the answers collected.

for development, actions bringing together scientists with international organizations, generating inter-institutional links and connecting scientists with decision- and policy makers. In conclusion, for the interviewees, SD practices are strongly related to the traditional diplomatic role of facilitating, bridging and connecting.

Excerpts from interviews regarding the practices of SD in Colombia:

- *Something that we have called "Agenda setting": Institutes like this can help carry out actions so that they can be considered for public policy, because they are science-based projects. I know more or less all the work of my researchers and they are really field researchers and for this reason Germany supports us because in Germany they cannot do field work on peace issues (Participant 7).*
- *For research work, understanding that I can access international funds when we generate alliances with international researchers to access those resources (Participant 11).*
- *From my work, from my research projects, I act as a bridge between academic communities in different countries and sometimes between decision makers (Participant 16).*

Conceptions on SD

The conceptions on SD by the actors are diverse (**Figure 3**); the most frequent conception among the participants is that SD refers to "building bridges and connections" for multiple purposes, namely, for international scientific cooperation for the solution of common challenges, for identifying strategic and political STI projects or for seeking international resources for STI. In this sense, SD is also seen as a mechanism to join forces with a common purpose, negotiate and generate connections for science or help a country achieve objectives with national interest. Other interviewees state more generally that SD refers to diplomacy to advance science, mainly supporting STI collaborations through diplomacy.

Finally, participants also commented that SD refers to science's use to make foreign policy decisions, being a strategic instrument to generate alliances between countries.

Excerpts from interviews regarding the conception of SD in Colombia:

- *I could say that SD is a union of efforts with a common purpose, between actors of the scientific community and of the country's foreign relations. It has a very important purpose, which is to achieve that link between scientific communities, global challenges, and how countries begin to work hand in hand with the scientific community to solve these global issues (Participant 4).*
- *SD is a way to facilitate communication between two important aspects: the generation of knowledge through the scientific method and the need we have to*

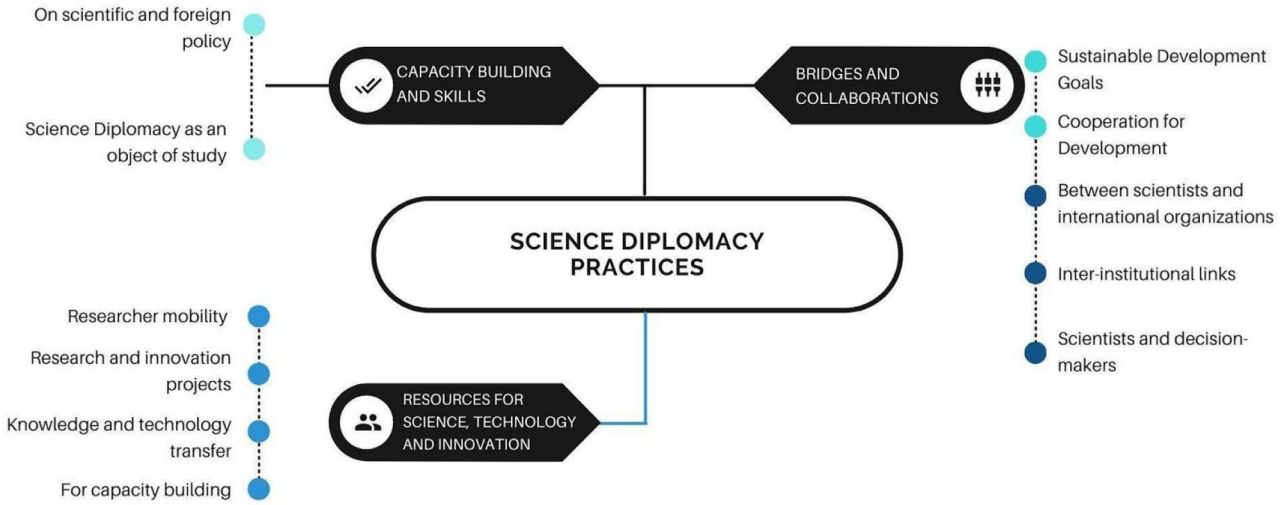

FIGURE 2 | SD Practices in Colombia. Participants were asked to indicate, from their own specific roles or profiles, in what kind of practices associated with SD do they engage. Categories are developed by the researchers based on frequency and similarity between the answers collected.

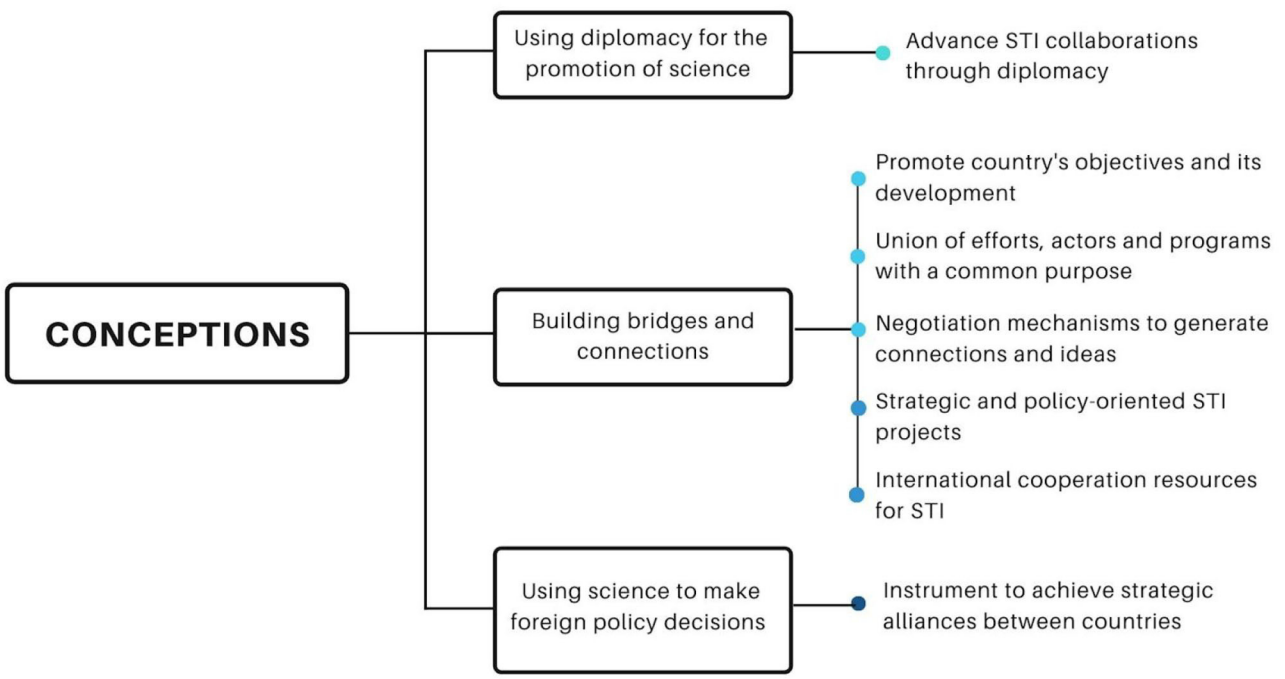

FIGURE 3 | Conceptions on SD. Participants were asked to define SD. Categories are developed by the authors based on frequency and similarity between the answers collected.

maintain a good relationship with our neighbors, through good communication and sharing benefits for society (Participant 8).

– *SD facilitates, enables and accelerates the development of STI, through the instruments that are established, such as agreements (Participant 15).*

Suggestions for the Future of SD in Colombia

Capacity building, meaning the developing knowledge and skills for SD, was identified as the most relevant suggestion, especially promoting scientists and other actors' training on SD. Besides, the participants expressed the need to have a multi-stakeholder

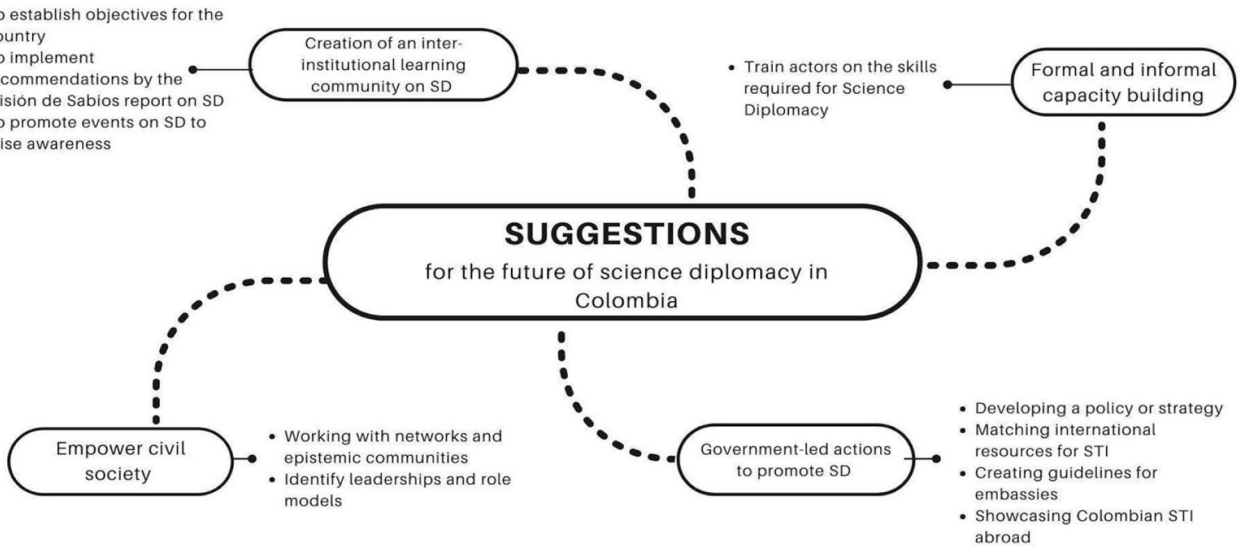

FIGURE 4 | Suggestions to strengthen the integration of actors. Participants were asked to provide suggestions on how to advance SD in Colombia. Categories are developed by the authors based on frequency and similarity between the answers collected.

working group on SD. Some participants stated that the working group should be led by the Ministry of STI and the Ministry of Foreign Affairs in order to have enough traction to attract other actors. Another interesting suggestion had to do with aligning SD actions with the guidelines and recommendations provided by the *Misión de Sabios*. In a way, a natural match is evident between SD and the recommendations of the *Misión de Sabios*, as the international dimension included in the 2019 report explicitly refers to SD as a mechanism to advance toward a more robust STI system in Colombia and its impact in the development of the country's knowledge economy (Misión de Sabios, 2019).

Likewise, the participants suggested official instruments to promote SD, such as the creation of a policy or strategy for the country. Some participants stated that such a policy should include clear guidelines for Colombian embassies to integrate SD activities in their agenda. An official instrument should focus on mobilizing international funds for STI, as well as promoting the Colombian STI production abroad. Finally, some participants also indicated that, given the multiplicity of actors that may play a role in this arena, civil society should be empowered by identifying leaders, champions and role models to inspire other actors. The role of networks and specifically multi-stakeholder groups like epistemic communities was highlighted as an excellent platform to advance toward an integrated strategy (**Figure 4**).

Excerpts from interviews regarding suggestions to strengthen the integration of actors in Colombia:

– *I have read the report from Misión de Sabios and there really are eight thematic axes with social and development impact. It is important that SD is articulated around these axes; In other words, all articulated efforts should be focused on these. One of the challenges of this report is to reach 2% of GDP in STI, through SD we can leverage resources to achieve this goal (Participant 1).*
– *It is very difficult because there is no clear concept. One way to strengthen is to visualize cases and initiatives. When one reads literature on this, this is not a science from hypotheses, this is inductive, it is based on cases. Cases should be shown and studied so that people know them and tell the sectors that they have played important roles (Participant 7).*
– *We need public and Government organizations to recognize and rely on organized civil society (Participant 16).*

DISCUSSION

The conceptions of SD exposed by the interviewees are related to the construction of bridges and alliances with different objectives, especially for the development of international scientific cooperation, and to build capacities in STI, as stated by Hornsby and Parshotam (2018) for the development of solutions to global and common challenges (Ramírez-Cabrales and Rueda Forero, 2020). Among the conceptions, it is also observed that SD supports the achievement of objectives of national interest, promoting collaboration between countries with an impact on academic development and foreign policy decisions, as exposed by Pantović and Michelini (2018). There is also the conception of integrating science with national needs and foreign policy objectives, as stated by Krasnyak (2020) in the case of Russia. However, it is necessary to find meanings for SD in Colombia. In sister countries like Brazil, for example, there is a clear focus of its country strategy on innovation diplomacy, taking into account the interest on the part of this country to intersect in the knowledge economy (Anunciato and dos Santos, 2020). Gual Soler (2020) exposes the need to find narratives,

conceptions and approaches for SD taking into account the Latin American context. In this sense, it is necessary to set building blocks for SD in the region and more particularly in Colombia.

When reviewing the actors of SD, the interviewees state that they range from the government sector, academia, industry, civil society and individuals to international organizations. In particular, the role of the Ministry of Foreign Affairs and the Ministry of Science, Technology and Innovation is observed, as well as other government entities of the national and regional order. Also other actors such as civil society, multilateral and international organizations and companies play a relevant role. Even entities such as universities and research centers are relevant actors in SD in emerging countries, as stated by Pantović and Michelini (2018). Non-traditional actors such as the diaspora, the indigenous and epistemic communities are gaining more relevance in the Colombian context and in emerging economies. This is articulated with what was stated by Thompson (2018), who explains the need to include non-traditional actors in national schemes of SD. As in the cases presented in the literature review, the inclusion of the scientific diaspora of emerging countries in SD schemes is imperative, especially for the execution of transnational scientific cooperation projects and to support the access to resources and experts.

On the other hand, SD practices in Colombia are divided into three areas: capacity building and skills development especially in STI, international resource management for STI and building bridges between the various actors of SD for projects and programs, oriented to the Sustainable Development Goals or global challenges, empowering and allowing a greater international visibility of emerging countries, as stated by Pantović and Michelini (2018). The development of human talent and research facilities are also a central practice of SD in emerging countries (Ezekiel, 2020). The focus of capacity building in STI, development of human talent and the exchange of knowledge and technologies was also observed in the case of India (Arunachalam et al., 2017). The use of SD to gain visibility and improve the image of the country through scientific production is one of the strategies also used by Russia (Ruffini, 2017).

Regarding the suggestions for the future of SD, capacity building must be further strengthened, especially by training scientists and other actors in SD skills adapted to the context of emerging economies. It is also necessary to create working groups where the different actors converge, in order to articulate the interests of the country and support the strengthening of science, technology and innovation systems, as stated by Pantović and Michelini (2018). The creation of a national strategy for SD is also required, which supports the mobilization of international resources for STI and includes the voices of the various actors, in order to promote the exchange and generation of new knowledge (Thompson, 2018). It is important to refer to the challenges identified by Gual Soler (2020), who states that Latin America must work to generate meaningful intersectoral collaborations for SD; institutionalize SD efforts, as well as generate learning roadmaps to develop the necessary skills in the region for SD among the involved actors.

POLICY IMPLICATIONS AND A TENTATIVE GOVERNANCE SCHEME OF SD FOR EMERGING ECONOMIES

Our research exposed the texture of SD in Colombia, a topic with a still varied and vague nature. However, specific conceptualizations regarding SD for emerging economies may be observed. According to the evidence, we can see that there are at least three rationales for SD expressed as conceptions:

A. Building bridges for, on the one hand, cooperating with other countries toward solving common challenges, and on the other hand, to join forces internally to help the country solve issues of national interest with the support of science.
B. Using diplomacy to promote the advance of national science.
C. Using science to make or strengthen foreign policy decisions.

Arguably, these rationales support or may support the main practices identified:

A. Collaboration practices for attaining sustainable development goals and for enabling multiple interactions: local-foreign scientists, exchanges between international organizations, between scientists and policy makers, among others.
B. Capacity building.
C. Mobilization of resources.

Finally, tentative futures expressed as suggestions for the improvement of the interaction and integration of actors in SD include:

A. Capacity building on SD for researchers, policymakers among others.
B. Creating a learning community for the development and promotion of SD.
C. Empowering organized civil society. Having this in mind, we suggest the following governance scheme, as an example, for further analysis and discussion.

As is shown in **Figure 5**, an SD policy strategy is set for adjusting or making instruments that can distribute specific roles among and balance the power between the actors involved in SD in both administrative state sectors: STI and foreign affairs. The package of instruments designed and implemented could be tuned around leverage points that (i) gives a preponderant role to non-conventional actors (indigenous communities, NGOs etc.) referred in the analysis section above; (ii) facilitates bridging activities between these type of actors and scientist between countries (south-south-north) for attaining sustainable development ambitions; and (iii) offer *ad-hoc* guidelines for operationalize SD with this perspective in embassies worldwide. The potential instruments intersecting, must be evaluated in their implementation from novel policy evaluation tools, enough holistic to understand the impacts of these mixes. Policy learning and change would be possible if the conditions are accurate,

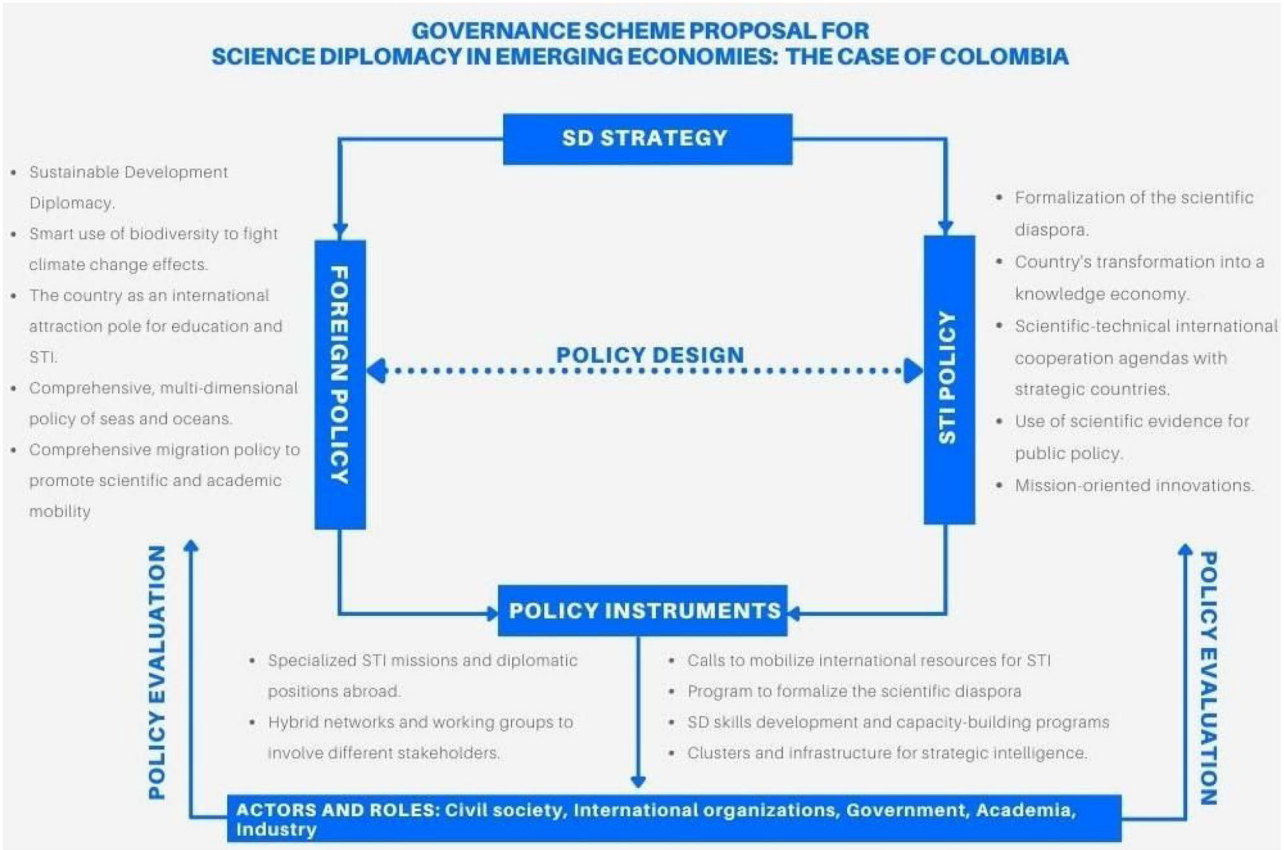

FIGURE 5 | Governance scheme proposal for SD in emerging economies based on the Colombian case.

which may result in the ulterior development of joint instruments for SD or specific ones that support the strategy.

This general overview would imply also a projection of how to proceed in terms of policy instrumentation which is not an easy task. The analysis presented in the precedent section can provide a general idea that inspires the analysis of bottlenecks and enable policy mixes intersecting foreign affairs and STI development aims (Rogge and Reichardt, 2013, 2016). Bringing together STI issues and foreign affairs under the light of a national development strategy foreseeing solutions of sustainable development in emerging economies, would help to understand how a governance of knowledge across borders can be deployed in late industrializing countries with high inequality rates (Rennkamp, 2011). Then, after considering overarching governance aspects that may support the articulation and coordination among actors, practices, and instruments between the two sectors, the following set of practical recommendations (see **Table 3**), is provided by gathering the suggestions from the local actors interviewed and those practices found in the literature and existing documented cases mentioned in previous sections. Recommendations are classified depending on the general SD practice they refer to, and the role each actor may play. Although some recommendations are ambitious, they can be further developed and serve as a tool to define the roles of each actor within SD, thus contributing to coordination and articulation.

This set of recommendations derived from our empirical analysis, beyond inspiring traditional instrumentation, such as international calls and programs to promote STI (diplomacy for science), leads to a reflection toward systemic policy instruments which promote and qualify interaction and strategic intelligence (Smits and Kuhlmann, 2004). This orientation applied to SD could reinforce or fulfill some of the still under construction Colombian innovation system functions and help to strengthen such a perspective in this country and beyond (Hekkert et al., 2007).

CONCLUSIONS AND FURTHER RESEARCH QUESTIONS

Results show that SD in emerging countries such as Colombia could be oriented toward developing the STI systems through international scientific cooperation and scientific advice to advance public policy and foreign policy decisions. From interviewees' perspective, SD refers mainly to the generation of bridges and connections, especially related to the development of STI, for the search of solutions to global challenges,

TABLE 3 | Set of recommendations for emerging economies in early stages of progress to advance SD schemes.

	Actors				
Practices	**Government**	**Academia**	**Industry**	**Civil society**	**International organizations**
Capacity building	Fund and participate in SD training in collaboration with academia Create a national intersectoral network or working group on SD Train diplomats and policymakers in SD	Generate a formal and informal academic offer of topics related to SD. Create doctoral and post-doctoral positions in SD Generate research groups on SD	Provide training on specific knowledge areas, such as the intersection of innovation and diplomacy Facilitate the transfer of new knowledge from industries abroad to the country for national interests	Provide training and organize events on SD topics, in order to bring society closer to schemes of SD Involve scientific diaspora in training activities as providers and beneficiaries	Advise governments on SD topics Open calls to develop projects and programs for Capacity building in SD between countries
Collaboration for SDGs/Global challenges	Create funding instruments for SD schemes Generate Mission-oriented and problem-solving research policies Participate in international negotiation scenarios Create networks and working groups with countries of the Global South to solve common problems	Tackle global challenges through the three missions: Teaching, Research, Outreach Generate specialized networks in order to provide knowledge and solutions Produce policy briefs to inform decision-makers	Provide knowledge and solutions through Corporate Social Responsibility Create action plans with clusters and associations to seek solutions to global problems	Transfer results of international collaborations to society Generate consultative committees for government entities, where diaspora participate. Introduce other kinds and sources of knowledge from indigenous communities, campesinos, informal workers, afro-descendant communities.	Generate spaces/events where scientists from different countries and government entities converge, to advance in the informed solution of problems
STI Resources mobilization	Generate bilateral programs with countries on issues of national, transnational or global interest Generate macro science-related events to make the research carried out in the country visible and attract researchers, investors and cooperation entities	Manage international resources within the framework of international scientific collaboration projects Create networking spaces between scientists from national and international universities and research institutions to apply for international calls and attract international resources	Manage resources with international companies for research and development projects that relate to national, transnational and global interests Support innovation diplomacy schemes for companies of all kinds Facilitate the transfer of technology of national interest to the country	Create incentives that promote international scientific collaboration for national, transnational and global interests Empower the organized diaspora by building specific work agendas for resource mobilization	Support the generation of SD schemes with transnational calls and funding for projects

Based on the literature review and the interviews' results, a set of recommendations was developed crossing the categories generated for actors and practices of SD in Colombia, reformulating country-specific issues to enable a possible adaptation in similar contexts.

as well as national objectives. Likewise, the conception of SD articulated to scientific advice given to foreign policy decisions and actions was exposed. SD actors in Colombia range from the government sector, academia, industry, civil society, and individuals to international organizations. The role of universities is highlighted, as well as the importance of the scientific diaspora (Hernández et al., 2003), epistemic communities (Knorr-Cetina, 1981, 1999) and the need to include indigenous communities in SD schemes. Taking into account that other countries have advanced SD strategies articulating their academic and scientific diaspora, it remains pending how Colombia will execute a comprehensive strategy that can include the diversity of actors and knowledge, especially non-traditional actors of diplomacy.

SD practices evidenced in Colombia are related to what has been observed in other emerging economies analyzed in the literature, since there is an approach toward the development of capacities and skills, the management and access to resources for STI and the generation of alliances for projects, as well as foreign policy objectives. For SD schemes to be executed in the country, it is necessary to create a national strategy, taking into account national priorities and needs, as well *Misión de Sabios*' roadmap for the future of STI and the insertion of Colombia in the knowledge economy. More instruments to promote and stimulate international scientific collaboration are also required, as well as empowering the diversity of SD actors, including civil society. On the other hand, learning roadmaps should be developed to generate capacities and skills in SD for all the actors involved in Colombia, as well as learning communities to share cases and exchange experiences. The practical proposals set out in the Policy Implications section can support both Colombia and other emerging economies in the implementation of strategies that include the policy combination approach as a possible governance scheme for SD.

When thinking about global challenges, the analyses conducted under this academic piece show an evident lack of explicit directionality for SD. Moreover, only superficial references about the Sustainable Development Goals and barely any kind of missions are explained, despite the recent *Misión de Sabios in Colombia*. The actors interviewed make no explicit mentions to justice, peace, energy or post-extractive transitions (Gudynas, 2011; Andrade-Sastoque et al., 2020; Ordóñez-Matamoros, 2020), a very humble explicit mention about indigenous peoples, and no explicit references to the informal economy, campesino or afro-descendant communities and their importance as knowledge, research, and innovation actors in a multicultural country like Colombia (Andrade-Sastoque and Balanzó, 2017). In general terms, local urgent problems with high global impact and people related to them are conspicuous by its absence and the apparent apolitical dye of the participants' narratives. This can be further investigated.

From a phenomenological multi-stakeholder perspective, this study suggests that a governance scheme deserves to be discussed and designed to establish a long-term strategy that proposes a policy mix between STI policies and foreign policies to tackle very local issues with high global representativeness. Also the analyzed views from the actors interviewed, still show a limited scope regarding rationales, activities and proposals to improve actor interaction for SD, in two senses: (i) the specific aims when referring to sustainable development and global challenges, and (ii) local urgent problems with high global impact.

Despite the potential of the SD governance general scheme for emerging economies presented and suggestions for policy instrumentation, still questions remain to be further investigated:

- *What rationales may be more accurate for SD in emerging economies?* Studies should draw on the current literature on SD and identify empty spaces regarding the specificities identified in emerging economies, especially regarding STI systems and dynamics. This may pave a way to enrich the SD discourse and develop more valid rationales for emerging economies.
- *How does SD practice contribute to solving global challenges without neglecting profound local problems?* An in-depth analysis of the logics behind the Sustainable Development Goals discourse in Colombia should be carried out, considering the analysis and recommendations from the *Misión de Sabios,* to focus the efforts and avoid neglecting local problems. Issues such as peace, energy or post-extractive transitions deserve further study.
- *Who can be new entrants or invisible actors involved in SD in emerging economies?* As explained above, actors such as indigenous peoples, informal economy workers, *campesino* or afro-descendant communities and their relevance as knowledge, research and innovation actors in a multicultural country like Colombia is a subject that deserves further analysis in the framework of SD studies.

Finally, we propose advancing in developing a specific narrative of SD in emerging economies like the Colombian one, which considers their specific context, conditions, needs and motivations. The interplay between rationales, practices and futures should be included in a SD policy that tackles local problems globally.

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: https://cutt.ly/ojnrRET.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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APPENDIX

TABLE A1 | Research participants and profiles.

Participant (P)	Profile
P1	Director from an International Office at a Colombian university.
P2	Director from a Research Institute.
P3	STI Independent Consultant.
P4	Vice-chancellor for research at a Colombian university.
P5	Head of International Relations from a governmental entity.
P6	Head of International Cooperation from a network of Colombian universities.
P7	Administrative Director from a Research Institute.
P8	A representative from the Pharmaceutical Industry.
P9	Colombian scientist and entrepreneur living in Brussels; has a company dedicated to promoting RandI collaboration between Latin American universities and Europe.
P10	Director from one of the sections at the Ministry of Foreign Affairs.
P11	Researcher at a Colombian University. Experience working at a US institution and with knowledge of public policy guidelines.
P12	Researcher at a Colombian University. Experience as a researcher in Europe and maintains close collaboration with European partners. Director of a doctoral program.
P13	Colombian scientist and entrepreneur living in Berlin. Designated a Research and Innovation ambassador for the city of Berlin. A company dedicated to promoting EU-LATAM links between academia and companies, mainly in the biotech sector.
P14	Director of the Diplomatic Academy of the Ministry of Foreign Affairs.
P15	Manager of RandI incentives at a large dairy company.
P16	Researcher at a Colombian University. Part of an European project focused on promoting and studying SD in Europe.
P17	The executive director of a Scientific Association. Currently doing research on SD.
P18	Former Minister of Environmental Affairs, former Ambassador of Colombia in Germany. Member of multiple national and international boards on global issues.

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Science Diplomacy in Ecuador: Political Discourse and Practices Between 2007 and 2017

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The decade 2007–2017 was a period in which the Republic of Ecuador experienced a series of economic, social, cultural, and political transformations. This research focused on science, technology, and innovation (STI) changes with implications for Ecuador's foreign policy. One of the core components incorporated was Ecuador's engagement with foreign governments and various regional and global actors to further scientific and technological advances. These far-reaching collaborations aimed to reduce gaps the country experienced in science and research. Moreover, to incorporate Ecuador into worldwide initiatives to tackle cross-border issues, such as climate change and environmental sustainability. These measures included academic and scientific mobility through an extensive scholarship program, the *Prometeo* Fellowship Program, the Yasuni ITT Initiative, the creation of emblematic research universities, and certain guidelines released by the Ministry of Foreign Affairs and Human Mobility of Ecuador related to these policies. This article reports on qualitative research in which President Rafael Vicente Correa Delgado's political discourse was analyzed, along with key STI policies promoted in his administrations. The objective of this study was to establish different implications from the Science Diplomacy perspective (SD); particularly, reflecting on the consistency between the political rhetoric and the policy implementation. Evidence suggests that the political discourse materialized into concrete STI policies that could partially explain positive transformations in various aspects of the STI context in Ecuador. Institutional strengthening, international mobility (inward and outward), increased scientific output, and foreign policy practices involving SD which can be traced in the studied period. SD strategies could have been more effective and lasting if they were not discontinued upon Correa's departure from the Presidency.

Keywords: science diplomacy, Ecuador, STI policy, STI capacity building, 2007–2017, Latin America, Science International Cooperation, sustainable development

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INTRODUCTION

The decade 2007–2017 was a period in which the Republic of Ecuador experienced a series of economic, social, cultural and political transformations. This research focused on the aspects related to science, technology and innovation (STI). Since Rafeal Correa's presidential campaign "knowledge revolution" fostering the international engagement of Ecuador STI was embedded in the political discourse (García, 2015; Aguirre, 2020). Emphasis was put on prospects of building a stronger domestic institutional setting and implementing learning processes from better

international practices in STI. Various public policies addressing different areas of the STI context in Ecuador were prioritized, with an intended impact on the foreign policy. During the period 2011–2017, Ecuador's international relations incorporated purposeful guidelines to foster closer collaboration with countries of greater scientific and technological advancement to reduce the considerable science and existing gaps the country experienced.

Regional and South-South scientific cooperation were also placed at the center of Ecuador's foreign policy, diversifying the nature, characteristics, and origins of its partnerships. Also, transboundary issues such as climate change and environmental sustainability were included in various STI policies. Among these policies were: academic and scientific mobility through an extensive scholarship program promoted by the National Secretariat of Higher Education, Science, Technology, and Innovation (SENESCYT), the *Prometeo* Fellowship Program, the Yasuni ITT Initiative, Yachay City of Knowledge, and Yachay University of Technology, Ikiam Amazon University, and science diplomacy related guidelines issued by the Ministry of Foreign Affairs and Human Mobility. In this context, this research was guided by the following questions: **(a)** Which experiences of science diplomacy can be identified in the political discourse and the STI policies implemented in Ecuador during the 2007–2017 period? and **(b)** Which nuances are especially relevant to Ecuador from the science diplomacy perspective?

The main objective of this work was to analyze governmental strategies for Science Diplomacy (SD) in Ecuador from 2007 to 2007, seeking to highlight the advances and limitations related to institutional transformation, international mobility—in and out of the country, scientific output (journal publications, and patents), and foreign policy practices. Most similar studies present and analyze one or another public policy strategy developed during the period analyzed. The present work adds a more comprehensive look, verifying, through bibliographic review, documentary analysis, and in-depth interviews with participating actors—directly or indirectly. This was done by analyzing the political discourse at the highest level and examining relevant public policies promoted between the years 2007 and 2017. This paper is divided into four main parts: **(i)** presents the main arguments and overview on SD studies, **(ii)** research methodology, **(iii)** the main STI policies and practices of scientific diplomacy and international engagement during the Correa Government, and **(iv)** the analysis of conditions for implementation.

CONCEPTUAL FRAMEWORK

Diplomatic relations involving STI do not have a consensual term that defines them and is commonly used by actors who participate and promote international relations and cooperation in the area (Acuto and Kaltofen, 2018). Two denominations are the most common: Scientific Diplomacy (Varela et al., 2017) or Science Diplomacy (Arroz and Mendoça, 2016). Although there is no consensus around the definition of SD, the Royal Society and the American Association for the Advancement of Science (The Royal Society-AAAS., 2010) state that SD mainly seeks to (i) inform foreign policy objectives with scientific advice; (ii) facilitate international scientific cooperation, and; (iii) use scientific cooperation to improve international relations between countries and to solve shared problems. SD studies recognize the importance of STI in international relations and collaboration between countries. Economic globalization and contemporary challenges, such as pandemics, climate change, global security, sustainable development, are common phenomena with shared risks and impacts globally (Beck, 1992). SD is conceptualized by Acuto and Kaltofen (2018) as the practice whose objective is to maintain, cultivate and expand relations between countries. Therefore, the role of scientists and scientific information in world politics permeates the spectrum of global policy like never before (Acuto and Kaltofen, 2018). Given this, STI through scientific collaborations has become an increasingly important aspect of world politics and a critical element to ensure that the design of public policies and political decision-making take scientific evidence into account (Fernandez-Poluch, 2015).

Some countries have institutions whose purpose is to create a dialogue between researchers and political decision-makers, like the Council of Finish Academies and Italy's World Academy of Sciences (Council of Finish Academies, 2019). Other countries have used SD to strengthen innovation capacities (Flink and Schreiterer, 2010), promote capacity via exchange in the fields of higher education and STI (Mendonça, 2015) or bilateral agreements for the circulation of knowledge and technology transfer (Dolan, 2012), among others.

Latin America is gaining more space on the world stage, especially in cooperation with emerging countries, such as the BRICS; however, its peripheral condition of development, as ECLAC studies have shown for a long time (Prebisch, 1987; ECLAC., 2011), has not allowed the region to achieve a more symmetric relationship with developed countries. The efforts undertaken by SD in countries such as Ecuador require minimally consolidated scientific, technological, and innovative capabilities and the ability to approach advanced research and development centers in other countries. Otherwise, these efforts are being increasingly slowed down or losing radicality in their goals due to the lack of material conditions to propel them.

Matus (1993) points out that governing does not depend only on the government plan or project. Two other conditions must also be considered: governance and government capacity. The Correa Government had very promising SD proposals and strategies. There was initially a support base in the legislature and other state and non-state actors, but the third element is just as important as the other two: government capacity. This refers to the intellectual, organizational, and technical capital that the government team and other organizations/institutions—as the scientific community—need to have to leverage and implement the strategies. These capacities need to be built and consolidated before strategies, and public policies are developed and implemented. Without these capabilities, the trend is that in the short and medium-term, the results will be below expectations. This is a very common and shared phenomenon among Latin American countries. Political immediacy is antagonistic to perennial state policies.

METHODOLOGY

The research data was collected by means of a qualitative methodology using three types of sources. First, to fulfill the study's general objective, bibliographic reviews and desk research were carried out. Second, to collect primary data, an instrument to conduct semi-structured interviews was designed and applied to key participants[1]. In order to elaborate the list of key participants, a strict set of criteria was established to include diversity and complementary/contrasting perspectives. The criteria were three-fold: (a) **Perspective**: Four complementary viewpoints: Foreign Policy, STI Policy, Scientific Community and International perspective. (b) **Deliverance ability**: middle to high-level decision-making position, and (c) **Relevance:** Significant exposure to the SD practices. The operationalization of the criteria is presented in **Table 1**. The potential participants involved those who: are/were public servants, officers, staff of public institutions, members of the scientific community, and/or directive members of an international (regional/global) organization. Also, those who had participated (or studied) directly or indirectly in the Correa Delgado Government's SD strategies. The themes addressed by the interviewees belong to the public domain and represent perspectives based on their own experiences. From a preliminary list of 35 potential interviewees, 25 responses were effectively collected. As part of the study, a search was made for guidelines issued by the Ministry of Foreign Affairs and Mobility, relevant to science, technology, and innovation toward the missions and members of Ecuador's foreign service. Special emphasis was placed on the Embassy of Ecuador in the Republic of Korea. This foreign mission hosted a pilot plan involving the appointment of an officer in charge of specific issues related to cooperation in education, science, technology, and innovation. That department was identified as Knowledge and Technology Transfer Analysis (MREMH., 2019). This position included duties and responsibilities focused on promoting science diplomacy initiatives in the bilateral relation Ecuador-Korea.

From the application of the semi-structured interviews, nearly 24 h of audio material was collected. Each interview session had an average duration of 45 min. Various platforms were used to conduct the interviews, including Google-meets, Zoom, and WhatsApp. The interviews were transcribed into text files, codified and analyzed to determine patterns, trends, common content, and contrasting views. In the discussion section of this article, block quotations are included to facilitate reading and elaborating on the main findings. Identities of participants are not revealed, instead the respective codes for each relevant participation are cited.

[1]This research was not submitted to the ethics committee because it involves interviews dealing with matters in the public domain, in accordance with Resolution No. 510, of April 7, 2016, in which it has the rules on the National Commission of Research (CONEP) non-mandatory submission and evaluation, as well as the interviewees will not be identified in the dissemination of the results, being attributed the codes and title of Participant.

KEY STI POLICIES AND THE INTERNATIONAL ENGAGEMENT OF ECUADOR

As a result of the inquiry, a group of flagship policies involving SD practices were identified. **Table 2** summarizes the findings, and this section discusses their content, objectives, and general scope.

The Political Discourse Addressing the International Engagement of Ecuador Science, Technology, and Innovation During the 2007–2017 Administration

President Rafael Correa Delgado's administration established a permanent and comprehensive system of communication that lasted during both of his administrations. This included three main components: regular meetings with representatives of the local and foreign press (*conversatorios*), mobile Cabinet meetings in the territories (*gabinete itinerante),* and, at the core was the *Enlace Ciudadano* (Citizen Link). The *Enlace Ciudadano* was a radio and television program (also widely streamed on social media) in which information about major policies were aired to the country. The first program was transmitted on January 20th, 2007, and the last on May 20th, 2017, with 523 transmissions during the entire decade. The *Enlace Ciudadano* was the main channel to inform the direction, measures, and details of the Ecuadorian Government's policy priorities during this period. The program's format experienced several modifications; however, the inclusion of science and technology policies was a constant practice. In the first years, there was a segment called "Announcements about Science and Technology." Various studies have highlighted how science, technology, and research were among the most recurrent topics in the program (Cañizares and Vanegas, 2012; Plua, 2014; Cerbino et al., 2017; Chavero et al., 2017). These citizen links were spaces for meeting the population; although the real benefits of such dynamics are questioned concerning what was invested in said spaces for dissemination and communication of government actions.

Frequent mentions about the international engagement of Ecuador in science and technology were also consistently present (Aguirre, 2020). Excerpts of a key Participant about the inclusion of STI international engagement in public interventions of President Rafael Correa Delgado:

> No doubt about the importance that various science and technology policies had in the public interventions of President Rafael Correa. Yachay [City of Knowledge and University] was a recurrent topic in the Citizen Links, also the transformations promoted in the building of scientific and research infrastructure in the country. Yachay was also at the center of the foreign policy and the international agenda in the travels of President Rafael Correa Delgado. Conversely, Yachay Public Company had an entire team responsible for planning visits, receiving international delegations, promoting cooperation agreements, and providing academic tours. President [Correa Delgado] visited Stanford, Harvard, and other world-class universities to build partnerships and make

> numerous alliances. The support to Yachay Tech, Ikiam University, and the SENESCYT was evident at the highest political levels (Participant EC10).

Interviewees also provided statements about the specific attention that was given to science and research activities in the international relations of Ecuador.

> President Rafael Correa Delgado had a permanent interest in promoting science, technology, and higher education cooperation in each of the international trips. He made sure to include in the official delegations accompanying the Presidential team, Congress people in the relevant Commissions to STI, top officers of SENESCYT, public universities, Yachay Public Company, and the Yasuni ITT Initiative during the years the policy was active. Also, the guidelines to prepare de agendas always included high-level meetings with authorities of the best universities in the countries of destinations, visits to world-class research institutions, and bilateral/multilateral encounters, when possible, to promote the emblematic universities, the transformation of the energy matrix and cooperation in different topics. For example, the promotion of closer ties in health cooperation with UNASUR [Union of the South American Nations] and research cooperation with various countries in Asia, particularly China and Korea (Participant EC11).

The *Prometeo* Program

The *Prometeo* Program was an initiative of the Ecuadorian Government implemented between 2011 and 2017. This program's main objective was to "develop research capacities of higher education institutions and governmental entities to strengthen strategic sectors of Ecuador" (Echeverria and Diaz Flores, 2018: 12). It consisted of the mobility of accomplished and experienced researchers through fellowships to engage in scientific activities in the Ecuadorian territory. The main research areas were energy and innovation, life and natural resources, economics, business education, administration, social and behavioral sciences, and art and culture. A total of 848 *Prometeo* Fellows participated in the program with monthly stipends ranging between US$4,300 and US$6,000 (Celi, 2019), which raised questions about the amount allocated to such actions. As some interviewees expressed: the general idea of the program was perfect. What should be analyzed is whether the investments correspond to the benefits received in short, medium, and long term. A participant with relevant experience in the *Prometeo* Program pointed out:

> A change was perceived in Ecuador, and that increase in investment had effects in [the process of] building scientific and research capacities in Ecuador. I think that the *Prometo* Program had great relevance to the government of Rafael Correa. Certainly, various shortcomings appeared during the implementation, and those failures attracted a lot of attention. For example, some fellows who claimed to have a doctorate degree were discovered in a lie and failed to prove such academic qualifications. These [shortcomings] happened because many changes were introduced very quickly. Hence the government did not have enough human power to implement all the new policies simultaneously, and the application and screening processes were unclear or simply involved incompetence of some mid-level officers (Participant EC2).

The *Prometeo* Program was widely advertised through the Foreign Missions of Ecuador accredited in different countries. Moreira-Mieles et al. (2020) and Van Hoof (2015) establish a relevant connection between the implementation of this policy and the significant increase in Ecuadorian scientific publications.

> The program was initiated to re-incorporate Ecuadorian scientists or the scientific diaspora, but later expanded to bring scientists from other nationalities. Ecuador managed to attract nearly 1,000 scientists who were incorporated in universities and public research institutes. Experts, both Ecuadorians who were abroad and foreigners who met certain criteria, came to Ecuador and shared experiences to develop the STI system (Participant EC13).

The *Prometeo* Program was ended in 2017, reporting an estimated investment of 54 million US$ dollars (Celi, 2019) with the last Fellows completing their activities in 2019.

Yachay—City of Knowledge and Yachay Tech

The new Constitution of Ecuador was approved in 2008. The National Development Plan *Buen Vivir* 2009–2013 provided a legal framework for President Rafael Correa (2007–2017) to promote a set of policies that sought to boost sustainable economic growth in a redistributive and inclusive manner. This included territorial inclusiveness and environmental sustainability. Two of these policies concentrated significant attention in this respect: Yachay—City of Knowledge and Yachay Technology University. According to official documents, Yachay's main objective was to become a city entirely dedicated to research, innovation, and production of various high-tech products and services (Yachay., 2012; Gómez-Urrego, 2019). The plan was to achieve this goal by bringing together public, private, and academic actors and institutions into one place. The realization of Yachay would enable the transition from an economy historically dependent on the extraction and export of commodities to an economy based on the generation of knowledge-intensive technologies and systemic innovation (Fernandez Gonzalez et al., 2018). The city project, located in the north of Ecuador, started in 2012 and should be completed in 2040 with the formation of the Yachay metropolitan area (Gómez-Urrego, 2019). The project, developed by the Korean firm IFEZ (Incheon Free Economic Zone), from the Republic of Korea was a big inspiration for Yachay. The guidelines contained in the project considered urban ecology, land use, mobility, urban dynamics, and civic integration (Ecuador, Plan Maestro, 2013).

The project sought to improve and create housing, commercial businesses, and communication networks that were not addressed by other strategic government projects. It

TABLE 1 | Perspectives—balanced interviewees viewpoints and sector of action and experience.

Perspective	Operationalization of the profile	No.
Foreign policy perspective	Former/Current Diplomat, Officer/Staff of the Ministry of Foreign Affairs, and Human Mobility	8
Scientific community perspective	Scholar, Researcher, Member of the Scientific Community, with relevant understanding of STI in Ecuador	7
STI policy perspective	Political analysts, Connoisseur of STI in Ecuador, Former/Current Public Officer in any of the identified SD practices	7
International perspective	Experienced professional, current/former representative - high-level officer in STI international initiatives, a regional organization involving the participation of Ecuador in STI processes	3
Total		25

TABLE 2 | Science diplomacy and key policy practices Ecuador 2007–2017.

Policy	Description	Science Diplomacy Features
Communication The Citizen Link	Permanent space prioritizing the communication of design, implementation, achievements, and challenges to emblematic STI policies	Constant interaction between stakeholders: public institutions, the Foreign Service, communication to the citizens, and engagement with the wider society
Prometeo Program	A comprehensive Fellowship program aimed at attracting accomplished and experienced scientists: foreigners and Ecuadorians residing overseas	To construct local research capacity and build international partnerships with their institutions of origin
Yachay Tech and Yachay City of Knowledge	The first planned city in Ecuador focused on the generation of a boosting STI Ecosystem with the creation of a world-class research university at the center	Planned and implemented based on successful experiences in knowledge cities, particularly Incheon Free Economic Zone and Silicon Valley, the policy included a very active set of foreign policy practices
Ikiam Amazonas University	An emblematic research university created as part of a biodiversity reserve in the Ecuadorian Amazons focused on global issues: climate change and environmental sustainability	Developed internationally benchmarked teaching, research, and community service mission envisioned as a living natural laboratory over an assertive practice of building global partnerships
Yasuni-ITT	Proposal to leave underground 846 million barrels of heavy crude oil found in the ITT fields, preventing the emissions of 407 million metric tons of carbon dioxide with co-responsibility by contributing half of the revenue coming from the international community	Transitioning from a fossil fuel-based economy toward a model of sustainable development, with widespread use of renewable energy, respect for biodiversity, and social equity with the involvement of foreign governments, multilateral organizations, responsible businesses, and citizens around the world
SENESCYT Scholarship Program	Nearly 20,000 scholarships benefiting outstanding Ecuadorian students for international mobility	Building the human power to establish a path for talented Ecuadorians to create a scientific (research) career learning from better international practices in higher education. The program involved active participation of the Ministry of Foreign Affairs, the international missions of Ecuador, and fostering cooperation between Ecuadorian and international higher education institutions with the support of SENESCYT
Embassy of Ecuador in Korea Appointment of the Knowledge and Technology Transfer Officer	The Ministry of Foreign Affairs and Human Mobility appointed a specific unit at the Embassy of Ecuador in the Republic of Korea aiming at promoting science and technology transfer within the scope of bilateral relations	STI as one of the pillars of the bilateral relations between the two countries, which influenced various areas such as investment (energy, infrastructure), preferential treatment in the promotion of several initiatives involving training, Official Development Assistance, cooperation

also planned to promote *Buen Vivir* in rural areas and strengthen food sovereignty, as well as diversity and cultural heritage for sustainable development. At the core of Yachay City was the Yachay University of Technology. In 2014, Yachay Tech received its first student population, with professors from universities and technological institutes from several countries. Based on the nucleation of Yachay Tech University, and its relationship with research institutes, technology transfer centers, high-tech companies, and several public and private institutions, Yachay City would be the first technological park in Ecuador. Its main contribution to this grand-scale policy would be to structure an arrangement between the university, research, and industrial complexes, capable of developing innovative companies and fostering entrepreneurship.

> At that time [2007–2017], the Yachay [City of Knowledge] was being prepared with this innovative approach. It was the first experience in Ecuador to have a city of knowledge, so it was impressive. A strong new institution was created: Yachay Public Company, to administer the entire long-term plan. The institution had a specific international cooperation team focused on fostering cooperation for higher education, science and technology (Participant EC10).

The city was planned to follow an industrial policy to promote technological development to export goods with high added value, which included an advanced strategy in the scope of international relations (Gómez-Urrego, 2019). Analyzing the trajectory of Yachay, Gómez-Urrego (2019) states that it was generated as a simple import or application of a foreign model (Fernandez Gonzalez et al., 2018), neglecting the trajectories of specific actors. This can be seen in the project's constant changes according to the political times and the actors involved.

Ikiam Amazon University

Ikiam means Jungle in the Shuar indigenous language. Ikiam Amazon University was established on November 12, 2013, as one of the four "emblematic universities" created during the 2007–2017 administration. The institution was established with the specific Law (Ikiam, 2020, paragraph, 1–2) and started its academic activities in 2014. Since its conception, Ikiam Amazon University was envisioned as an institution to develop "internationally benchmarked teaching, research, and community service missions within the Ecuadorian Amazon (Wise and Carrazco, 2018)."

The University figures highlight that 62.75% of its research projects are internationally funded, denoting the importance of the intensive networking and international partnerships promoted by Ikiam Amazon University is the result of a series of policies aimed at strengthening the Ecuador higher education system, especially intertwined with the transformation of the energy and productive matrices of the country. The guiding principle of the university activities seeks environment sustainability and systemic competitiveness at the core of academic objectives. The implementation of this policy faced several challenges, such as not having laboratories and equipment at the beginning of their activities, which limited the institution's progress and highlighted the fact of having the largest natural laboratory in the world by its geographical location. Ikiam is an institution with coverage at the national level, but with particular emphasis on the region where it is installed—the Tena municipality in the Napa province. Wise and Carrazco (2018:342) maintain that this is a "case of top-down state-driven development model in which this university was established on principles of excellence, impact, and relevance." An interviewee with relevant experience within Ikiam Amazon University indicated:

> Ikiam is an example of internationalization. Since the early years of its structuring and organization stage, good practices from world-renowned universities were used as a benchmark. Three particular institutions provided guiding standards: Stanford University, Columbia University and Brazil's National Institute of Amazon Research INPA. Currently, it has signed 133 agreements with national and international counterparties. The scope and mission of Ikiam is different from that of Yachay Tech, that is why these two emblematic universities do not compete among them. While Yachay Tech was planned as a core component of a Planned City of Knowledge, Ikiam was envisioned as a natural reserve element. Ikiam promotes interaction of the academic community (students, professors, researchers) with high-level universities (Participant EC3).

From the science diplomacy perspective, the creation and implementation of Ikiam Amazon University is relevant considering the nature of the issues placed at the core of the institution's goals. Bacquet et al. (2018) reflect on the unpostponable environmental demands and pressures to generate science in a challenging socio-economic context such as the one present in a developing country like Ecuador. The reality built from the presence of Ikiam, opened possibilities of higher education to a distant population from the central cities of the country, but also generated spaces for discussion concerning the public administration of the invested resource; since the questioning for high salaries to certain advisers, did not stop generating disagreements among some sectors of the population.

Yasuni-ITT

The Yasuní-ITT Initiative was another official project from 2007 to 2013, during the mandate of Rafael Correa. This initiative conditioned the maintenance of the Intangible Zone decreed in 1998 by the Jamil Mahuad government in a sector of the Yasuní National Park located between the Ishpingo, Tiputini, and Tambococha oil exploration quadrants. The intangible zone was decreed by the Mahuad government (1998–2000) with the purpose of not interfering in the territories of the native inhabitants located in the Amazon of Ecuador and keeping the biosphere reserve away from the oil exploitation that is carried out in various areas of the Ecuadorian Amazon rainforest. During the Correa Delgado government, it was proposed to leave part of the Amazon intangible zone unexploited conditioned to a compensation mechanism for the income not received. By not exploiting oil resources and keeping crude oil underground to the carbon market, the compensation would be made by the international community to the Ecuadorian State under the criteria of ecological economics, environmental economics, and natural resource economics. The Yasuní-ITT Initiative had five goals:

> (1) effective conservation and avoidance of deforestation in the protected areas of Ecuador and other remaining ecosystems; (2) reforestation, afforestation, natural regeneration, and appropriate management of one million hectares of forest owned by small and medium landowners in lands that are currently threatened by degradation; (3) a change in the national energy matrix that increases the renewable energy generation and the national energy efficiency through energy savings; (4) social development in the areas of influence for the Yasuní-ITT Initiative, with programs for education, training, technical assistance, and the generation of productive

> employment in sustainable activities such as ecotourism and agroforestry; and (5) research and development in science, technology and innovation for the generation of goods and services based on bio-knowledge; and in addition, to implement the integrated watershed management (Vallejo et al., 2015: 176).

To develop the initiative, Ecuador designed foreign policy guidelines to promote co-responsibility of developed countries that are the largest global polluters, and with this, the Ecuadorian State would commit to leaving underground, indefinitely, around 856 million barrels of oil in the Yasuní ecological reserve, to avoid the emission into the atmosphere, of 407 million metric tons of carbon dioxide (which would be produced by the burning of these fossil fuels). In exchange, financial compensation was expected from the international community for a fraction of the estimated value for 50% of the profits received if these resources were to be exploited (about 350 million dollars a year). The funds raised by this operation would be reinvested in Ecuador in three lines: Management of 19 protected areas, a national reforestation program, and the energy matrix transformation. External contributions would go to a trust fund administered by the United Nations Development Program and, through an international body, the monitoring and implementation of the objectives necessary to make the transition to a new development strategy would take place (United Nations Development Programme (UNDP)., 2010). As compensation committed by some countries intended to impose conditions, of which most of the funds would be managed by a trust, several discrepancies arose between the potential contributors and the Ecuadorian government, for which reason the initiative was halted. The Yasuni ITT failed to be completed; nevertheless, it allowed for broadening the dialogue on power asymmetries and global governance.

SENESCYT and the Mobility Scholarship Program

Based on article 26 of the Republic of Ecuador's Constitution, education is established as a right, and it is a responsibility of the State. At the same time, it is classified as "[...] a priority area of public policy and state investment, a guarantee of equality and social inclusion and an essential condition for good living [...]" (National Constituent Assembly., 2008). In this sense, the Organic Law of Higher Education in its article 182 (National Assembly., 2010), establishes that "[...] the National Secretariat of Higher Education, Science, Technology and Innovation (SENESCYT) is the body that exercise leadership in the public policies of higher education and coordinate actions between the Executive Branch and the institutions of the Higher Education System [...]," this became the legal foundation for the implementation of the public policy by the SENESCYT for the promotion of human talent in higher education. It is worth mentioning that through Executive Decree 555 dated January 9, 2015, the Institute for the Promotion of Human Talent was created, which came to replace the Ecuadorian Institute of Educational Loans and Scholarships (IECE), which had been created in 1971. The scholarship recipients became those "[...] contemporary heroes who go to study and learn in other places to return to their homeland and build a better nation for everyone [...]" (Speech by President Rafael Correa Delgado in the award of SENESCYT Scholarships 2012).

The primary purpose of this mobility of scholarship holders was to form and accumulate the human power needed for the development of Ecuador. It was compulsory for the awardees to complete their studies and return to Ecuadorian territory since human talent was considered necessary for the generation of wealth. All these actions were based on the National Development Plan *Buen Vivir*, of which its main axes guided the change of the national productive and energy matrices.

> An attempt was made to respond to a historical debt that appeared with strong demands for higher education from marginalized minorities and who today disputed democratization at this level. But perhaps, a quota policy thus conceived and implemented responded better to the needs and demands of globalization, the new knowledge economy and new links between education and the economy—or within the Ecuadorian reality—to the needs of the Plan of National Development than to the subjects, their communities and histories and more real and deeper intercultural senses (Di Caudo, 2015: 210).

International relations were important in the mobility of Ecuadorians abroad. There was access to education of excellence in the best universities in the world. From the government's vision, its contribution was to induce many people to advance in their university education and seek improvements in the Ecuadorian territory upon their return. Investing on a "knowledge revolution" that would transform the productive matrix of the entire territory, going "from being a country of finite resources to generate infinite resources, because the cognitive matrix is fundamental for the change in the productive matrix" (official speeches cited in Di Caudo, 2015: 216). Among the main competences of the Under secretariat for Strengthening Knowledge and Scholarships, was the strategic management of public policy that supported and strengthened the training of excellence in all branches of knowledge, both in the facilitation of scholarships and the *Prometeo* program.

The public policy linked to professional and academic training, intended to contribute especially to those who otherwise could not have continued their training at another level. However, this distribution by quotas came with cultural shock to the beneficiaries since, on many occasions, this mobility was also accompanied by emotional loneliness.

> This pilot quota plan designed and developed from public policy and implemented in a group of institutions to include young people ended up excluding them as direct beneficiaries. The meritocratic logic emphasized talent, formal education, competence, excellence instead of existing differences and alterities such as social class, ethnicity, sex, and disability (Di Caudo, 2015: 216).

With an estimated public investment of more than US$ 500 million (SENESCYT., 2012), the 2007–2017 administration implemented this extensive scholarship policy training

Ecuadorians at the postgraduate level in the best universities worldwide. Such implementation required an intense dialogue with universities, academics, and international study centers, involving particular attention from the diplomatic missions of Ecuador on its growing scientific diaspora abroad. The passage of time helped to see favorable results, including situations that could be worked on in a better way, to be able to offer better management of resources, greater transparency, and better distribution of such benefits. At the time of conducting this research, the investment for such items has been seriously affected, to the extreme of being almost nil.

> SENESCYT focused on supporting education of Ecuadorians in master's and doctoral programs overseas. Over 20,000 scholarships were awarded in total. There was also a program of insertion of these graduates to be absorbed in Ecuadorian universities upon return. These strategies shorten the time for the evolution of our scientific output. Ecuador jumped from <300 publications a year in a particular database to publishing 2,000 in the same platform (Participant EC13).

The central objective of the program was favorable, and it allowed the incorporation of a highly trained group. However, the question is that upon return, the country was not prepared in its institutions to achieve full placement of the talents trained. There was a deficiency in that regard. Deficiency that is still perceived since many of the people trained failed to join the promised job.

Diplomacy for Science, the case of the Embassy of Ecuador in Korea

The Embassy of Ecuador in Korea represents a case of diplomacy for science in view of the particular guidelines and measures taken by the Ecuador Ministry of Foreign Affairs and Human Mobility to support various initiatives within the bilateral relation. The Embassy devoted particular efforts through the regular functions of career diplomats, in addition to the appointment of an officer in charge of issues specifically related to cooperation in higher education, science, technology, and innovation, and that had performance indicators relevant to the practice of science diplomacy between Ecuador and Korea. The model of rapid socio-economic development experienced in the Republic of Korea was a recurrent reference in the political discourse of Rafael Correa Delgado, particularly with respect to the role that research and development and the strong STI policies played in industrialization of this country (El Universo., 2012). In 2010, a State visit was organized by President Rafael Correa Delgado to follow a very comprehensive agenda dominated science and technology cooperation (Embassy of Korea in Ecuador., 2020). As a result of the preparations, the execution, and the development of the several areas of cooperation in STI reached during this visit, various processes unfolded.

The Korean model has been considered one of the main inspirations behind Yachay City of Knowledge, a major industrialization policy "*Refineria del Pacifico.*"

> In September 2010, Rafael Correa Delgado embarked on a state visit to Korea in search for alliances, investment, and international cooperation in a variety of topics ranging from renewable energy to investment in the *Refinería del Pacífico* (oil refinery to be built in the coast of Ecuador). The team behind the reconceptualization of the project of Yachay managed to include in the president's itinerary a visit to KIST (Korea Institute of Science and Technology) 44 and Incheon, which were, in their minds, materializations of the ideas they were developing. During the trip to Korea he [President Rafael Correa Delgado] visited several cities, including Songdo, and a variety of industrial complexes, to negotiate cooperation between the two nations in various topics, mainly around energetic investment from Korea in Ecuador. Correa Delgado became convinced that this was the kind of project his government needed: a project which combined both the educative transformation his government had promised and the change in the productive matrix, which had become the guiding sociotechnical imagined within the government (Gómez-Urrego, 2020: 130).

Interviewees also referred to the significance of the Korea-Ecuador bilateral relation for STI initiatives:

> To my knowledge, creating a position specifically in charge of attending issues of bilateral cooperation in science and technology only occurred in the Embassy of Ecuador in The Republic of Korea. The initiative was innovative and meaningful. One of the elements that justified the position was the deep and close involvement of various Korean entities, including public institutions and private firms, in various critical STI policies. For example, the Incheon Free Economic Zone IFEZ, Daedeok Innopolis, from the city of Daejeon, were heavily involved in the planning of Yachay City of Knowledge, and SK energy had a key role in projects aiming at energy development in Ecuador. A particular emphasis was placed on students and researcher's mobility between the two countries. I remember there were Korean fellows under the *Prometeo* Program as well (Participant EC14).

The STI initiatives promoted in collaboration between the two countries received attention from Ecuadorian institutions in their territory. They had closed coordination with the Staff of the Mission of Ecuador in Korea.

> An entire division of SENESCYT and YACHAY Public Company were devoted to attend the numerous common projects between Ecuador and Korea. The number of graduate students mobilizing to pursue master's and doctoral degrees in Korean universities grew exponentially during 2012–2105. Also, the number of delegations from public officers, trainees, business people, entrepreneurs going and coming between the two countries was significant in the same period. Everything needed important efforts to keep in check results, otherwise, it was hard to keep track of all the activities that were taking place. Unfortunately, the intensity and diversity of the cooperation diminished as the economic and political global context shifted since 2016. In addition, priorities on behalf of the Ecuadorian government change with the new

administration after 2017, showing that STI cooperation does not occupy a high position in terms of priorities anymore (Participant EC6).

DISCUSSION AND FINDINGS

Consistency Between the Political Discourse and Practice

A first analytic category is related to the consistency between the political discourse and the materialization of government proposals and actions. Ideally, a democratically elected government presents a Government Plan, which will, over time, be materialized in strategies and actions that allow the achievement of the pre-established objectives. However, for several reasons (i.e., political, material, financial or legal), what is observed is no linearity between proposal and action. There is some disruption between these two moments or contexts.

Excerpts from the interviews show this process and explain the difficulties and reasons that prevented, to some extent, the practice from accompanying the speech and political proposal. The material conditions and circumstances encountered made it difficult for the planned actions to be carried out satisfactorily to the fullest extent.

> I think there was consistency between speech and action in the first years of President Correa's administration. First, they laid the foundations that would allow them to carry out actions. Then, they took concrete actions to improve science and technology sectors; however, as time progressed, it became evident that the discourse was amplified. I mean... the discourse was greater than actions. There were many plans, programs, and policies proposed, but the implementation and, therefore, achieving results fell short due to multiple factors. There were documents and planning instruments, and the problem was that there were not enough conditions for them to succeed. The sudden changes, raising the standards introducing, performance indicators in STI were disruptive and interpreted as burdensome. For example, the search for external sources of income for universities to support research was encouraged, but the system made the execution of external funds very difficult. The levels of bureaucracy and red-tape processes were enormous. On paper, everything seemed viable, but in practice, it was difficult to implement (Participant EC1).

In the excerpt above, it is possible to verify that insufficient financial resources and the excess bureaucracy were two aspects highlighted by the interviewee and that, to some extent, are among the factors of difficulty in implementation. Another widely commented topic by the interviewees was an overly optimistic speech made concerning the SD practice. The organization of face-to-face visits, the composition of its delegation, and the construction of the official agenda, for example, were carefully designed.

> Probably the presidential speech was exaggerated, but it should also be mentioned that there was an undeniable stress placed in STI areas of the policy in his administration. I believe that the level within the country in relation to science and technology rose significantly. Professors were required to have completed graduate studies, it may sound obvious, but indeed, the universities were forced to invest in research and personnel, to raise their standards (Participant EC4).

Using the concept of Herrera (1975), which spells out discussions related to the implicit and explicit policy in STI, it is evident in our analysis of SD—from the interviews—that the Correa Delgado Government had an alignment between its implicit and explicit policy.

> I think that the political discourse was consistent with the policy practice to a significant extent. The Ministry of Higher Education, Science, and Technology creation which previously did not exist was important. The newly established institutional setting allowed the universities to find themselves in need to make progress in their standards, advance faster and improve their quality. A university evaluation system was proposed, and also funds and other forms of support were generated at the public policy level. Ecuadorian students had access to mobility alternatives. There were funds for research to bring samples for analysis and engage in joint research projects. However, not everything was positive. The expectations were too ambitious for our daring realities.... So, the problem with exaggerating the discourse is that you generate expectations that are not real, and I think that played against the very same process in the long run (Participant EC2).

Although the Correa Government had decision makers' desire and prioritized SD strategies and practices, which are extremely important elements to undertake a new diplomacy logic, it is clear that they are not enough. Barriers and difficulties were imposed at different times, such as financial resources, personnel, and university capacity. We will see some of these limitations and/or challenges in the next section.

Underlying Transformation in the Science Diplomacy Practices of Ecuador 2007–2017

All the interviewees agreed that since the return to democracy in Ecuador in 1978 until 2006, the international engagement of Ecuador in science and technology was absent from the political discourse and the government initiatives. This is supported by literature (Herrera-García, 2016; Herrera-García et al., 2019), which explain how during several administrations, the prevalence of extreme neoliberal policies in all aspects (economy, health, education, etc.) resulted in the elimination of nearly all competencies in science, technology and innovation policies from the public sector, except modest measures taken by the administration of President Jaime Roldós (1979–1981) and Rodrigo Borja (1989–1992) which were focused on domestic agenda (Campaña, 2020). It was until the period 2007–2017 when the administration of Rafael Correa Delgado incorporated science and technology policies at the center of its discourse and practice (Salazar Diaz, 2016). Various interviewees referred to the importance of establishing modern responsive regulations to facilitate the engagement

of Ecuadorian stakeholders in the STI in scientific activities, both in the domestic and the international spheres. These transformations went beyond the executive branch of the government. The establishment of a responsible legal framework for science diplomacy required the decisive involvement of the legislative branch.

> The new Constitution of 2008 favored STI policies to a great extent. It was necessary to recognize the importance of such policies for the development of Ecuador and update our legal framework foundations in the country. The Government National Plan *Buen Vivir*, which created an institutional and legal framework, allowed all these processes to occur with established planning. It was an obligation for the allocation of public funding, for example, all proposals involving research were articulated to the pillars and objectives of the National Plan (Participant EC1).
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> Between 2007 and 2017, there was a strong impulse of international relations in higher education, science and technology, and innovation... In the context, especially the field of higher education, this first stage referred to the recognition of qualifications and degrees obtained in foreign institutions. At a later stage, we began to look for many relationships linked more to the cooperation of funds for access to scholarships because Ecuador had a strong scholarship policy during the period 2011–2016, in which significant resources were invested (Participant EC13).

A portion of the nuances of Ecuador's legal framework is related to the recognition of ancestral knowledge and traditional practices of wisdom, which is generally disregarded in western scientific practices (de Sousa Santos, 2010).

> The constitution of 2008 represented a turnaround in the legal framework of Ecuador. It expressly incorporated several features corresponding to STI. This was, perhaps, the first Constitutions in the history of Ecuador that textually includes the right to benefit from scientific progress and its applications, which consists of national human rights. It also created the system for Ecuador to participate in international science and technology. The system comprises the institutions of higher education, plus research institutes that articulate science and technology with traditional [indigenous] knowledge. The ancestral inhabitants of Ecuador generated knowledge that has always been hierarchically subordinated and many times not recognized. Context such as the Ecuadorian science and technology landscape required articulating locally generated traditional knowledge with internationally accepted scientific metrics and standards. The entire higher education system was also shaken to its core. In 2010, the organic specific law for higher education was approved to introduce compulsory research activities that had been completely abandoned in Ecuadorian universities. The SENESCYT created a whole set of incentives, programs, funds, and mechanisms. The institution began the allocation of funds through competitive calls. The legal framework also created several public research institutes (Participant EC13).

Another consensus among interviewees was the importance of institutional building, after or at least in parallel to establishing an STI suitable legal framework. Before 2007, some institutions were created. However, the entire STI system had limited participation of the public sector, and the budget allocated to these sectors was minimal (Herrera-García, 2016; Herrera-Garcia, 2018).

> The Science and Technology Council in Ecuador followed a different logic than that observed in neighboring countries such Brazil, Chile or Argentina. In Ecuador its creation was a consequence of the prevalence of the neoliberal paradigm with minimum state involvement in socio-economic issues. The Council obeyed the neoliberal stage of development, yielding poor results, limited only to some sectors such as agriculture. But in all the other fields, it was totally disconnected from the country's needs, without access to financial resources or key policies, so an organ was created that did not generate results. Evidence of that was creating an organ in charge of science and technology, yet the legal figure was a private foundation FUNDACYT that resulted from a multilateral loan from the Inter-American Development Bank. The Washington Consensus embraced by Ecuador did not consider STI as sectors for the participation of the State. Before 2007 Ecuador did not have research infrastructure in the country; one of the main issues or weaknesses that the university system had was the education level of professors. Few of them had postgraduate degrees and doctoral training, so the human capacities to conduct research did not exist. FUNDACYT failed to articulate the higher education system with broader development goals. That is why the creation of SENESCYT in 2007 with way stronger mandates, size, structure, resources, and the highest support of power reflected positive results for the STI Ecuadorian system (Participant EC13).

Interviewees also identified different moments in the transformation of STI sectors in Ecuador even considering the 2007–2017 decade in which this study is focused. Participant EC20 proposed three key moments:

> Regarding the 2007–2017 STI policies, I see a clear differentiation in three stages: First, 2007–2010 the institutional building that introduced deep transformations requiring close coordination between the legislative and the executive branches of the government. Various laws were issued, institutions created, policies designed and the human power at different levels were appointed. and the foundations for the coming phases were laid down. This included an integral intervention and reorganization of the higher education system. A second moment 2010–2014 in which further policy implementation was sought with an identifiable assertiveness in science and technology. And a third stage, 2015–2017 in which the innovation component was further incorporated although the government experienced a decrease in public support and pressures by external factors (changes in the international prices of commodities and a major earthquake) shifted priorities in the public agendas (Participant EC20).

Conditions for Effective Implementation of Science Diplomacy Practices in Ecuador 2007–2017

Building a Baseline of STI Capacities

Understanding the baseline in terms of STI capacities in low and middle-income countries from the southern hemisphere is an important departure point to engage in international STI processes. In the case of Ecuador, as some participants indicated, the scientific and research capacities were minimal before 2007. Moreover, the political discourse and the public agenda did not include these areas as part of the national priorities.

> Our scientific capacities in Ecuador before 2007 were deficient, even for regional standards in South America. There were very few opportunities to develop research in all aspects, including human and institutional capacities. Local universities offered few opportunities for graduate studies. The opportunities came from external scholarships and international cooperation. If someone intended to pursue academic specialization, people had to look for international funding. The only other option was self-financing or applying for educational loans. There were no international scholarly exchanges as such. We were merely recipients of certain assistance and external collaborations, donations in a very vertical dynamic of international cooperation (Participant EC4).

Context matters, and it also involves the dynamics affecting the international engagement of countries with the scientific development characteristics of Ecuador. Similar conditions are shared by other nations in Latin America. In this sense, minding the numerous gaps in different aspects is critical for effective SD practices.

> The language and timing of bureaucracy, politics, and diplomacy, differing from that of science, is another issue that scientific diplomacy seeks to reconcile in terms of how these two worlds move in a way that advances. For example, some international scientists from the *Promoteo* Program arrived in Ecuador with expectations to work intensively and put in place all their valuable capabilities, but they found in a very arid context. Many of them possibly started activities without equipment, reagents, laboratories, and minimal conditions to start activities. There were no human resources available, and there was not all this context to facilitate high-level scientific research. Frequently, universities and scholars in Ecuador don't understand why you have to present the results of an investigation at a conference. Therefore, they don't provide authorization nor financial support, which created obstacles to make progress. How can such capabilities be built? Ecuador had 10 years of significant effort as a country and many resources directed to science and technology with valuable but limited results. Certainly, the science level improved, with constant pressure to publish more articles, in Correa's time. After the end of his presidency, fewer universities continue to have that momentum (Participant EC9).

> One of the biggest contributions to STI from President Correa Delgado was achieving social awareness of the importance of these sectors for the development of the country. Before his administrations such topics were absent from the public agenda. Thanks to various of its policies stakeholders were created with interests and involvement in science and technology (Participant EC20).

Constant Interactions Between Stakeholders From Different Sectors

SD policy and practice assume as a condition of success, a permanent interaction between stakeholders (Lorenzo et al., 2020), which is critical in a context such as Ecuador. Developing countries tend to have fragmented STI systems in which the scientific community, political actors, and private firms follow separate agendas and attend differentiated and opposed interests. In these conditions, foreign policy finds limited room for action. This is why the integral approach observed in the policy guidelines of Ecuador's international engagement in the 2007–2017 period provides an interesting case of coordinated efforts. Certainly, the challenges experienced in the aligning of diverting interest of multiple stakeholders were also mentioned.

> Beyond the will of the authorities, international collaboration required active participation of professors, researchers, and administrative staff, on behalf of universities and research institutes. We needed to reach further using the usual approach: signing a series of agreements, with no follow-up and measure of results. The *Prometeo* Program sought in its first phase, to attract people with high profiles to Ecuador by giving them sufficient funds. It allowed them to interact with local researchers and other professionals to create scientific networks. The number of scientific publications increased, networks were also created to link other researchers at the national and international level. In various cases, the Fellows were also placed in private firms (Participant EC3).
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> There was a comprehensive national plan to change the productive matrix of Ecuador. The 2007–2017 administration aimed at Ecuador ceasing to be a country that is exclusively a producer of raw materials and commodities. Instead, turning to industrialization policies, diversify its production and export more sophisticated and added value goods and services. A critical component was the transformation of the energy matrix; therefore, significant resources were invested in building hydroelectric plants. Before 2007 Ecuador had to import electrical energy, as the country relied mostly on fossil fuels. It was even common to experience power shortages despite having possible sources of electrical energy. Just as the government was invested in hydroelectric power, it should have been an immediate action to train specialized technicians to operate the power plants. We need to be strategic with different sectors: energy, hydrocarbons, higher education, and science. Other sectors, such as the production sector, began to talk about training. There were dialogue tables that were super interesting, in which the famous coordination of strategic sectors was present (Participant EC4).

Various participants indicated that an aspect that needed more attention to assess the effectiveness of the SD practices during the Rafael Correa Delgado administration was the involvement of the private sector. The improvements in the interactions between public organization, political actors and civil society in STI related policy is recognized in general, however, the involvement of companies and private capital seem to have fallen short.

> A significant shortcoming in the various S&T policies during the administrations of Rafael Correa in Ecuador's government was the limited involvement of the private sector. One of the explanations of this limitation was the high centralization of the initiatives in the executive branch of government. Even universities were directed which left little room for companies and private firms to engage (Participant EC16).

Diversification in the Building of Partnerships

A key feature of Ecuador's foreign policy during 2007–2017 was the diversification in the building of partnerships. Before 2007, the international agenda was concentrated in relations with powerful countries in the North, particularly the United States and Central Europe. However, during Rafael Correa Delgado's administration, STI international engagement, although also involved initiatives with traditional partners, expanded and diversified the partner countries. In particular, seeking closer relations with countries in Asia: China, Korea, Russia, Turkey, and Latin America: Argentina, Cuba, Brazil.

> Between 2007 and 2017, Ecuador was an attractive partner with many opportunities to generate international STI collaborations. European countries like Italy, France, and Spain, were aware that Ecuador changed its mission and was growing well, and therefore many people had intentions to support that growth. Ecuadorian people were in many scientific international institutions. They could be found in the United States, United Kingdom, France, Italy, and Spain. The Ecuadorian community's perception overseas began to change from the previously known migrant work in domestic services to science-related careers (Participant EC2).
>
> I think the country's positioning in its foreign policy strengthened, especially in the Latin American region. South-South cooperation on these issues was emphasized (Participant EC4).
>
> Ecuador invested significant resources in developing its science and technology sectors, but we also needed that cooperation to share the investment pressure with the international community. Hence, much of the foreign relations in this context involved the idea of seeking financing from cooperation agencies, universities, or partner governments in general to finance scholarships. The focus was placed on strengthening ties with those states and organizations that were the priorities. The trend or the political program of Correa Delgado's government was to achieve a South–South STI cooperation perhaps. Ecuador became a drive in the creation of the Union of the South American Nations Council of Science and Technology [UNASUR]. The mandate was to extend the agenda that we had been promoted to expand at a regional level. This was done in terms of international relations and integration. Certainly, relations with the northern countries were also pursued, especially in Europe. It was considered a milestone for Ecuador to collaborate with one of the most competitive research centers in the world, located in Switzerland. SENESCYT supported that engagement process. It involved several contacts, visit trips, it was a permanent component of the agenda. Finally, it was possible to sign an agreement with the European Council for Nuclear Research (CERN). That enabled several Ecuadorian students and scholars to join different activities of the organization. In addition, direct cooperation was achieved between CERN and the National Polytechnic School of Ecuador, which resulted in the establishment of two research centers in Ecuadorian territory. SENESCYT worked closely with diplomats from foreign embassies accredited in Ecuador, and also with the Ecuadorian missions located abroad (Participant EC13).
>
> I believe that positioning Ecuador's interests in STI with the involvement of foreign policy was more productive as we managed to diversify our partners. We had offices in Eastern European countries that were willing to collaborate with us. Hungary offered scholarships for co-financed Ecuadorians, which alleviated the heavy investment needed for opening more educational options overseas. Ecuador also benefited from scholarships and other STI cooperation from Portugal, China, and Russia. This also gave us a lot of support, with the USA continuing our collaboration but became less dependent. With the European bloc there were more defined schemes, and negotiating equality was more complicated. The complexity of regulations and standards were considerable. Nevertheless, Ecuador in those years [2007–2017] experienced intense transformations (Participant EC6).

Challenges for Science Diplomacy in Ecuador 2007-2017

Instability in the STI Policy

Developing countries such as Ecuador share features of instability in their political and socio-economic processes that inevitably have a detrimental impact. Various interviewees indicated that, from their different perspectives, progress in the design and implementation of well-structured STI policies was undeniable during the 2007–2017 administration. However, sudden changes in the policy trajectories were a persistent characteristic easily observed in the successive governments of Ecuador since 1979, which remain present to a different extent in the administration of President Rafael Correa Delgado. Herrera-Garcia and Franco-Crespo (2019:27) sustain that "The STI policies [during 2007–2010] were unstable since there were several short-term policy initiatives, and that the implementation was far from the ambitious rhetoric and the great objectives set, limiting themselves to two instruments: postgraduate scholarships abroad and financing of research projects and development." Some interviewees referred to instability in the STI policies, as we can see in the excerpts below:

> I think you have to divide the STI transformation in Ecuador into two periods, 2007–2014 was one period, and from

> 2016 onwards, things changed, of which the momentum was maintained for a while but then it declined in the last 2 years. I am very pessimistic, unfortunately, reality makes me so. The processes that took place to improve the STI context were nearly reversed, university accreditation and devaluation systems were erased. Regulations about standards and quality protocols were mandatory, then in 2017, changes were introduced from the new administration, and now they are voluntary. There were modifications to the regulations, and the change of government was an opportunity for those who resisted change to return to the starting point (Participant EC2).

Herrera-Garcia and Franco-Crespo (2019:27) sustain that "The STI policies [during 2007–2010] were unstable, since there were several short-term policy initiatives, and the implementation was far from the ambitious rhetoric and the great objectives set, limiting themselves to two instruments: postgraduate scholarships abroad and financing of research projects and development." Admittedly, despite the challenging socio-economic and political conditions that do not allow the continuity and expansion of STI policies, which are essential to support science diplomacy, it is verified that there was an effort in the Correa Delgado Government. This was dismantled from 2018 with The Organic Law of Higher Education. This panorama can be corroborated by the EC4 Participant's comment below:

> The National Plan had indicators and guidelines with which all actors had to be aligned with. From being a nation with weak knowledge production history, Ecuador aimed at becoming a benchmark experience in the Latin American region. The country actually made progress if we compare the STI context in Ecuador before 2007 and after 2017. Regrettably, a backward heading path has been taken by the current administration (Participant EC4).

Unfortunately, this instability scenario in the continuity and improvement of public policies is not peculiar to Ecuador. It is a very common phenomenon in the Latin American context, which has countries with low democratic maturity in their societies, with social inequalities that are quite aggravated, thus also apparently reducing the urgency in investing in STI policies.

> The centrality that STI policies had in the National Development Plan and the vehemence that the President observed when addressing them in his discourse had a double edge: gathering public support and making those policies a target of attack from political adversaries. The long-term nature of the intended transformation presented a complex context, making the initiatives vulnerable during transition of power and political instability. Grand endeavors such as Yachay City of Knowledge required planning, the fulfillment of different phases and stages, but the pressures to produce short-term results and the political rush due to high expectations generated clashes, tensions, and disputes, which brought a toll into the project (Participant EC10).
>
> The science diplomacy practices in Ecuador still find it difficult to transform episodic and circumstantial interventions into systematic and integral policies. The period we are discussing [2007-2017] involved stability and sustained efforts, however once the leadership of President Rafael Correa was replaced, the initiatives were halted (Participant EC21).
>
> Transformations in the science and technology context of a country takes time. The multiple pressures from urgent problems affecting societies such as Ecuador frequently divert attention and resources from those sectors, which ultimately affect the speed and depth of the changes. From an international perspective we observed the sound policies and well-intended plans promoted by the 2007–2017 administrations, but also recognized antagonistic forces and the inertia of the development process introducing ups and downs to the pace of progress in the international engagement of Ecuador in S&T (Participant EC23).

Mismatch in STI Capacities in International Engagement of Ecuador

Various policies such as Ikiam University and Yachay Tech were part of a broader set of capacity-building strategies that were aligned with international STI capacities. The ambition of these projects and other STI actions, policies, and strategies marked the Correa Government. The perspective that the social and economic development of a country derived from scientific and technological development boosted measures that would encourage the constitution of a robust research and development system that is adequate to the country's development.

As the Science Without Borders program in Brazil, Ecuador adopted a policy of training and qualifying human resources within the scope of Universities. The financing of research and development projects for the training of graduate students (master/doctor) abroad placed Ecuador on the international stage. The qualification of a scientific community is one of the most important pillars of building a country's STI capacities. However, it is necessary to recognize that the establishment of an internationalized scientific community and a set of elements, which support a country's scientific and technological capabilities, require steady actions and constancy in government measures to promote science, technology, and innovation.

As we can see in the excerpts below, the government's effort is recognized, yet it is also pointed out there was a lack of better understanding of how universities work and how equipment and technological infrastructure are important for the constitution of research and development infrastructure.

> I think they are long-term effects; both are different models. Ikiam is embedded in a nature reserve, which is the largest natural laboratory in the world, in a way, it is a correct approximation. Yet, the project neglected the acquisition of technological equipment. I think there were many management errors among other mistaken decisions, a gap between the conception in its operation. I think there was a lack of knowledge of how universities work, they said that in <10 years it would be among the 100 best in the world, which is impossible; that shows ignorance of the academic system, of how research works. I believe that people

> involved thought it was possible [...].Yachay was a project for a technological society that was going to be a development pole for the country. For a project this grand and ambitious to succeed key questions needed to be asked. For example, all public research institutes in the country were going to be located in Yachay, an area of mountains. The planners were also putting the institutes that do oceanography, research on oceanic marine culture in the same infrastructure; it was illogical (Participant EC1).

Another widely commented aspect also refers to the time required for the maturation of the scientific bases necessary to leverage a national system of science, technology, and innovation. Participants EC2 and EC9 point out—below—these challenges and possible obstacles.

> As a country at the stage of forming the scientific bases necessary to, at some point be able to flourish, sustained efforts are required. This is not something that overnight, then this support for training scholars was important at that time and it lasted about, 5, 6 years. It helped strengthening the universities. From abroad, I could see how the universities in my country were improving (Participant EC2).
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> The truth is, the gap is huge. I believe that we should have governments with more vision in this regard. Some people have no idea what science and technology means. I believe that the Correa Delgado government did yield results. Science awareness improved, and the administration brought and generated technology in the country. Then this idea of raising the quality of the universities, he created a body that monitors and supervises the quality of the universities, that body continues to function, I don't know how efficient it is, but it continues to work (Participant EC9).

It is clear that the "impetus of the Correa Delgado Government" (Participant EC9) brought a new perspective to the scientific community and to universities. The experience of these actors, in spite of any obstacles experienced and the retrogression of these measures in later governments, marks a new era for scientific and technological complexity.

Dealing With Resistance to Change

It is also necessary to address some aspects of resistance to the transformations brought about by the internationalized STI measures proposed by the Correa Delgado Government. Some university actors questioned these measures and even encouraged a certain resistance to the proposed changes, especially with regard to the Universities' quality assessment and measurement systems. Comments on the motivations of this resistance can be seen in the following excerpts:

> There is a group that I think never agreed with outsiders coming to Ecuador in the scientific sphere for multiple reasons. They saw their status threatened somehow. They had gotten used to the fact that you already have an appointment and were never worried about working harder because nobody could replace them. Having outsiders entering the scenario meant they also had to improve their performance, and then it disrupted a status of immobility that universities had, some even began to talk about "scientific colonialism," people who come with other ideas to impose processes on us. At this point, there was a change, there was also rejection from the people here, possibly because they did not understand much about the importance of this change demanded by competitive practices in academia worldwide (Participant EC2).

Without wishing to strain the discussion of the extent to which these mobility processes and the formation of the Ecuadorian scientific community are constituted by scientific colonialism, it is worth pointing out that this discussion is already recognized. Herrera (1975), one of the founders of the Bariloche Movement, already pointed out this process as a trend in Latin American countries for emulation of ST and economic development in central countries. The consequence of the emulation of scientific agendas is the atypicality and anomaly of the STI policy, which barely meets national challenges (Dagnino, 2016; Spatti et al., 2021).

> I think that from the technical perspective, the policies were correct. Clearly, there is a cultural context where they settle and where there is and maybe more complexity, so you look at the policies and see the results, and they are policies that put Ecuador in a better position. Change frequently causes certain dissatisfactions. On the one hand, there was resistance within the institutions to the arrival of these foreigners because they put the efforts into question in individual and group terms what those university communities have done. I think there was also a lack of cultural understanding. I think we can say that the difficulties existed, but the results were positive. In the end, many Ecuadorian academics ended up learning a lot from the people who came from abroad (Participant EC13).

Another mapped resistance was that related to the reorganization and restructuring of the institutional settings. Participant EC18 elaborated in the local perception of "re-foundation approach" taken during the early years of the 2007–2017 administrations, not only in the STI areas, but also to the wider national spectrum. Fields such as public health and vaccine production attempted to shift from the "pharmacological *maquila* approach to build a R&D-based production ecosystem, but the local vested interests boycott the process." Similar mentions were done in regards to the agriculture, energy, and mining sectors.

Science Diplomacy Human Power (Staff, Foreign Service)

The last analytical category refers to the strong engagement of human resources in Science Diplomacy missions and actions. Most of the interviewees recognized that, in the analyzed period, the strong strategy coming directly from the Presidency and the immediate high-level collaborators managed to set policy and measures into practice. As for the Ministry of Foreign Affairs, mix appraisal was shared by interviewees who remarked some positive aspects while others highlight difficulties encountered. Participant EC3 pointed out, there was an engagement by the President and his team to foster international cooperation.

> The pursuit of science, technology and higher education collaborations permeated the international relations of

> Ecuador between 2007 and 2017. The President was the one who always led the composition of the agendas. The economic, political, and diplomatic agendas incorporated science, technology, and innovation components. In that sense, very important agreements were signed at the international level. I don't have the exact figure, but many countries with which alliances and cooperation were created (Participant EC3).

The creation of a diplomacy school, together with important changes in the choice of representatives of the Ministry of Foreign Affairs and representatives in diplomatic missions abroad, were measures that demonstrate the seriousness with which the Government dealt with diplomacy. In the excerpt below, the participant highlights these measures and his experience in actions that involved political and scientific engagement in solving national problems.

> An attempt was made to transform the Ministry of Foreign Affairs regarding who the country's representatives were, or at least how these representatives were selected. A school of diplomacy was created to facilitate broader access to sectors of the society. Traditionally, Ecuadorian diplomats were members of elite families, specific affirmative actions were implemented to increase the participation of women, indigenous population and people from unprivileged backgrounds. These changes were positive, but consumed the first years in office with newly appointed diplomats taking time to understand the dynamics of international engagement in S&T. As a member of the Ecuador scientific diaspora I found it difficult addressing topics such as ocean acidification and the involvement of Ecuador scholars and diplomats, in part explained by ignorance but also lack of interest at the scientific level (Participant EC2).

In addition, there was an effort to engage public research institutes and universities in science diplomacy discussions and in scientific and technological cooperation projects. In this sense, institutional building became a recurrent issue during the studied period.

> In 2007, the Ecuadorian Agency for International Cooperation was created, and it became dependent on the National Planning and Development Secretariat precisely with the vision that the issue of international cooperation, in general, had to respond to the objectives of national development. It was still an instrument for international relations but under the logic of integrated planning. The main objective was directing every international cooperation effort to strengthen local capacities. Within this logic, the creation and development of local capacities was already seen with a larger vision (Participant EC10).

The commitment for international cooperation actions to promote higher education, science, and technology was explicit. The most emblematic project was Yachay Tech, a city of knowledge, which became one the flagship policies of the Correa Delgado Government. Participant EC10 understands that an impulse was given that had never been given, since the implementation of a university evaluation system, funding for training human resources for the production of science and technology, until the implementation of coordinated work with embassies and the consulates to promote the Yachay project as an unprecedented scientific-technological park in the Latin American scope.

Some participants offered a critical perspective of the challenges that SD practices encountered within the Ministry of Foreign Affairs and Human Mobility in terms of restrictive attitudes in the exercise of diplomacy and called attention to the importance of expanding the understanding of diplomacy.

> The Ecuadorian institutional context in which diplomacy is exercised is very particular. Worldwide, it is accepted that career diplomats might have stronger incentives to perform efficiently based on stability and dedication to building their career path. Meanwhile temporary appointed foreign service members could obey to conjuncture pressures rather than consistent institutional guidelines. This has not been the case of Ecuador, in which the prevalence of a conventional diplomatic practice has been restrictive leaving little room for a modern attitude in diplomacy. In other words, we continue limiting our diplomacy to trade and commerce, culture and official development assistance, without reaching beyond these interests (Participant EC19).
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> In the diplomacy promoted by Ecuador, we find a predominance of a restrictive perspective to the content of the Vienna Convention with focus in the promotion of economic (commercial diplomacy) and cultural (cultural diplomacy) interest of the country. Narrow view which has not accompanied the evolution of other aspects of diplomacy such as international scientific collaboration and engaging in global issues (Participant EC21).

CONCLUSIONS

The explicit terminology "science diplomacy" might not be found in the political discourse and the policies implemented in Ecuador during the 2007–2017 decade; however, the analysis of the rhetoric and policies of this administration offer clear evidence of the emphasis placed on the science international engagement of the country. This period marked a clear turning point in Ecuador's recent history when significant transformations in the science, technology, and innovation contexts were intended from the highest level of decision making.

Evidence suggests various flagship policies encountered in the interface between science and foreign policy. Also, some of these policies aimed at fostering Ecuador's participation in tackling issues within regional and global reach. The constant exploration in the intersection of domestic STI interests and the international relations of Ecuador had different intensity and depth levels depending on the scope and dynamics of interactions between the stakeholders. Nonetheless, the highest levels of political leadership (President, Vice-president, and Ministerial level) permanently incorporated signs of support for SD.

Building STI domestic capacities proved to be a necessary condition for the science international engagement of Ecuador,

and at the same time, the nuances of this case confirmed that SD practices have plenty of opportunities to be directed precisely to such purpose in developing countries: the construction of a stronger STI baseline. SD strategies could have been more effective if Ecuador had more consolidated scientific, technological and innovative capacities and, of course, an STI Policy more structured. In Latin American countries, discontinuities between governmental administrations do not allow cumulative movements to be constituted. Another important element is about government capacities. Most Latin American Countries need to strengthen technical bureaucracies to achieve cognitive and administrative capacities in light of the ambition and boldness of government projects. In any case, even without the use of "science diplomacy" as an explicit conceptual framework, the intersection between STI policy and foreign policy is palpable during the 2007–2017 administration in Ecuador.

The pursued science diplomacy practices in Ecuador during 2007–2017 can partially explain positive transformations and measurable improvements in various science and technology indicators, including but not limited to: institutional strengthening, international mobility (inward and outward) scientific production (publications, patents), and foreign policy practices involving science. Further research is recommended to further the discussions of SD studies and perspectives from the global south realities. Findings in this study indicate that, while the political discourse in STI was decisive, and financial resources were purposefully channeled to the identified SD policy practices, a series of challenges present in the Ecuadorian context diminished the extent of effective implementation. Consequently, results and impact were also curtailed.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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OPINION
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Call to Action: Supporting Latin American Early Career Researchers on the Quest for Sustainable Development in the Region

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INTRODUCTION

Science diplomacy could be broadly defined as scientific interactions to tackle common concerns (science in diplomacy). These collaborations could result in positive interaction between countries (science for diplomacy) or use diplomatic interactions to increase scientific knowledge and collaboration between countries (diplomacy for science). Besides their diversity, Latin America and the Caribbean (LAC) countries have some general features that could facilitate the use of science diplomacy to strengthen their interactions for the technological development of the region (FECYT, 2017; Gual Soler, 2020). For that, each component of the scientific system in the region needs to be analyzed, creating the basis to suggest recommendations as part of the regional science diplomacy and science policy strategies. Early and mid-career researchers are crucial in the scientific system, and they create the future scientific capacity of the region. Thus, the design of science diplomacy and science-strengthening policies is critical to inform national and regional policymakers with unified and customized recommendations to improve the systems that host these ECRs.

ECRs are broadly defined as researchers under 35 years old who obtained their highest degree within the last 5–10 years and or do not yet have a permanent position (Bazeley, 2003). In the LAC context, we expand this definition (ECRs-LAC) to up to 10 years post PhD and younger than 45 years old, because compared to other regions, careers of ECRs-LAC begin later (Kreimer and Vessuri, 2018; Education at a Glance, 2021) due to older age at the beginning of the doctorate, delayed graduation rates, educational structures, and differences in opportunities. These factors impact the international competitiveness of ECRs-LAC and the scientific attractivity of the region. ECRs-LAC issues are a direct concern to researchers and institutions, and to the development

strategies of LAC countries. A supportive system that enables a sustainable research career provides an important scaffold for knowledge and technological development in local or regional contexts. LAC countries have diverse levels of scientific development; but overall, the percentage of GDP allocated to research, technology, and innovation is <1% (up to 10 times lower than most high-income countries) and has been decreasing in recent years, leaving research systems in a non-competitive position (IDB, 2010; RICYT, 2019; Bolaños-Villegas et al., 2020). Less opportunities for scientific education, training, and academic positions are proposed to contribute to the high mobility of doctoral students and ECRs out of the region (Lemarchand, 2015). ECRs-LAC can be split into three mobility groups based on their professional trajectories: (1) those who pursued their professional development in their home country, (2) those who undertook part of their training abroad and then returned to their home country, and (3) those who left their home country to pursue a career and remained abroad (scientific diaspora) (Pinto-Baleisan and Delage, 2017). These career paths could inherently influence access to opportunities. Are LAC scientific systems able to compete in current knowledge production dynamics and respond to the motivations of ECRs-LAC mobility?

Some LAC countries (i.e., Brazil, Mexico, Chile, and Argentina) have their own renowned doctoral programs, allowing many ECRs to pursue their professional development at home (mobility group 1) (Lemarchand, 2015) and attracting PhD students from other LAC countries. In recent decades, many LAC governments have invested in fellowship programs that allow ECRs to undergo specialized training outside the region[1] (IESALC, 2019). This has created unprecedented academic exchange and mobility. Such programs have had a significant impact in countries without scientific doctoral programs; but without parallel local investment, newly trained ECRs (mobility group 2) return to scientific systems that lack sufficient infrastructure and funding agencies to support their reinsertion and fully harness their training[2] (Ramírez, 2018) (**Table 1**). The factors influencing ECRs-LAC mobility have not been fully harnessed to inform policies that better support their career trajectories for personal, national, and regional benefits (Dalton, 2008). Some efforts have addressed the effect of internationalization of LAC scholars through reinsertion programs that facilitate employment upon returning home[3] Civic organizations have contributed by presenting evidence and proposed new policies impacting ECRs-LAC[4]. Independent and governmental agency-supported networks of LAC researchers create additional mechanisms of communication between researchers in the region and the diaspora[5] (Gaillard and Gaillard, 2014) (**Table 1**). At the regional and ground levels, ECR organizations like the Global Young Academy (GYA), The World Academy of Sciences Young Affiliates Network (TWAS-TYAN), and National Young Academies (NYAs) continue to create new opportunities in the field of science diplomacy for LAC countries.

Through this opinion, we encourage reflection and dialogue on the issues that the ECRs-LAC face. By considering these challenges and actively participating in studies about ECRs, we hope to create strategies to better support the next generation of science change-makers in the region. The success of this study requires collaboration between ECR organizations and policymakers. Harnessing the human capital that ECRs-LAC represent is crucial for the region to meet the United Nations (UN) 2030 sustainable development goals[6].

CHALLENGES AFFECTING ECRS, HOW THE SITUATION IN LAC IS DIFFERENT

Globally, ECRs represent a more vulnerable group in the field of research, facing specific challenges, which may also vary between regions. The overall increase in doctorate graduates and deficient creation of new professional opportunities are resulting in increased ECR job insecurity, jeopardizing the continuity of ECRs in academia or allied industries (Editorial, 2016; Interview, 2019). These issues have been exacerbated worldwide by the COVID-19 pandemic, leading to more professional precarity, less funding, and increased job insecurity (Byrom, 2020; Editorial, 2020; Paula, 2020). The effect could be stronger in LAC, a region with lower investment in research[7] (Bolaños-Villegas et al.,

[1]Examples of mobility programs in LAC that are part of a governmental scheme: https://www.senacyt.gob.pa/becas-internacionales-e-insercion-de-becarios/
http://www.dipres.gob.cl/597/articles-163122_r_ejecutivo_institucional.pdf
https://minciencias.gov.co/convocatorias/formacion-y-vinculacion-capital-humano-alto-nivel/convocatoria-doctorados-en-el
https://www.conacyt.gob.mx/index.php/becas-y-posgrados/becas-en-el-extranjero/estancias-posdoctorales-y-sabaticas-en-el-extranjero
http://www.pronabec.gob.pe/modPublicaciones/2020/Memoria%20Anual%202018%20-%20Pronabec.pdf.

[2]Programa Inserción de becarios SENACYT-Panama https://www.senacyt.gob.pa/wp-content/uploads/2017/02/PIB-2015-Reglamento.pdf

[3]For example, the RAICES program (Argentina): https://web.archive.org/web/20110902184504/http://www.raices.mincyt.gov.ar/documentos/Programa%20Raices%202011.pdf. In Chile https://www.conicyt.gov.cl/pai/category/lineas-del-programa/atraccion-de-cientificos-en-el-extranjero/
https://www.conicyt.gov.cl/pai/category/lineas-del-programa/insercion-en-la-academia/.

[4]https://globalyoungacademy.net/activities/the-global-state-of-young-scientists/, https://redeschilenas.cl/2021/01/03/dic-2020-boletin-rech/v.
https://anip.cl/uncategorized/el-decalogo-de-la-investigacion/?_thumbnail_id=495 https://anip.cl/insercion-laboral-de-posgraduados/
https://www.csic.edu.uy/sites/csic/files/documentos/el_apoyo_a_la_repatriacion_de_cientificos_desde_la_universidad_de_la_republica_oriental_del_uruguay_%282%29.pdf.

[5]Examples of LAC diaspora networks: https://redeschilenas.cl/redes-miembro-rech/
https://cancilleria.gob.ar/es/actualidad/boletin/redes-de-cientificos-argentinos-por-el-mundo
https://www.cientificos.pe/
http://redtalentos.gob.mx/index.php

[6]Innovation and technology fuel economies, diverse metrics point toward investing in science for economic development: https://publications.iadb.org/publications/spanish/document/Ciencia-tecnolog%C3%ADa-e-innovaci%C3%B3n-en-Am%C3%A9rica-Latina-y-el-Caribe-Un-compendio-estad%C3%ADstico-de-indicadores.pdf.

[7]https://www.cgap.org/research/data/2018-funding-latin-america-and-caribbean
https://www.cepal.org/es/comunicados/america-latina-caribe-rezagada-investigacion-desarrollo
https://www.imf.org/en/News/Articles/2020/08/12/na081320-lack-of-human-capital-is-holding-back-latin-americas-growth

TABLE 1 | Towards a better understanding of the challenges ECRs-LAC face to support the development of stronger scientific systems in LAC.

Challenges/questions	Actors*	Ways forward/recommendations
Current circumstances faced per professional mobility groups	Governments, scientific societies, and ECR organizations	Studies to understand the current circumstances of ECRs-LAC and strategic plan to equal opportunity for mobility
Access and availability of higher education opportunities	Governments, scientific societies, and ECR organizations	Increase national graduate programs and create new regional graduate programs and fellowships
Repatriation/reinsertion	Governments, scientific societies, and industry or start-up incubators/stimuli	Programs that consider not only funding but also infrastructure and institutional support
Connection with the diaspora	Governments, research institutions, scientific societies, industry or start-up incubators, diaspora organizations, and ECR organizations	Science diplomacy programs to increase collaborations and exchanges taking advantage of strengths of the science from the new country of the diaspora. Agreements and funding for partnerships. Facilitate access to research facilities
Assessing the quality of ECRs-LAC research	Governments, scientific societies, and ECR organizations	Determine what the quality of research is and its scientific or societal impacts and create better research assessment to generate a more holistic view of research performance that benefits all research fields
Impact and internationalization of ECRs-LAC research	Governments, scientific societies, research institutions, ECR organizations, and international organizations	Design specific strategies for the region on open access of research (for LAC researchers to have access to international production and for LAC publications to be read globally) publication cost, international collaboration in a win-win design (no "colonial science")
Quantification of the public policy of research in the region	ONU, CEPAL, research institutions, and Ministries of Science or relevant divisions	Assess current policies and their actual impact/value in the research systems through a science policy lens to modify existing research-related policies or create new ones accordingly

Here, the main challenges/questions of ECRs-LAC, along with the diverse actors that should be involved in addressing such challenges, and ways forward/recommendations to have a supportive research environment for ECRs are presented.

[*] Examples of ECRs and diaspora organizations and networks: Global Young Academy (international ECR organization), TYAN-TWAS (international ECR network from an international scientific academy), Redes Chilenas-Chile (independent ECR network including diaspora), RAICES-Argentina (governmental agency program for diaspora), RedGlobal MX-Mexico (independent diaspora network established with governmental support).

2020; Pérez Ortega and Wessel, 2020). Regional ECR-focused studies conducted by the GYA in Brazil, ASEAN (Association of Southeast Asian Nations), and Africa (Beaudry, 2014; Geffers et al., 2017; Neumann, 2018) have highlighted specific regional challenges. Mobility and career internationalization during ECR training are common. However, these are increased in Africa and LAC regions (Beaudry, 2014; Geffers et al., 2017; Neumann, 2018; Rivero et al., 2020) where international mobility is a necessity due to a lack of appropriate graduate programs or topic-specific expertise in the home country of an ECR (Castillo Jaén, 2005; Lemarchand, 2015). A better understanding of the mobility of ECRs-LAC could help design through diplomacy for science, regional strategies that support improvement in graduate programs, and research careers in the region (**Table 1**). This will enable ECRs-LAC to have increased opportunities to access quality training, the underlying premise creating the Instituto de Educación Superior de América Latina y el Caribe (IESALC-UNESCO).

The ECR trajectories defined earlier could also impact access to further opportunities. ECRs-LAC hired as postdoctoral fellows usually confront disadvantages based on financial constraints, lack of institutional support and retirement savings, and low salaries compared to young scientists in similar positions in developed countries (Righini and Mota, 2018). Further, the LAC private sector does not report R&D expenditures (Islam, 2014) to create opportunities for this workforce.

While many challenges of ECRs are global, research "ecosystems" (higher education and research institutions, government agencies, private sector, and relevant policies) in LAC contribute to the isolation of issues that stem, for example, from international mobility. A trend in some LAC countries to assign more value to professionals who have international training may cause bias in job prospects, hiring processes, salaries, performance evaluation (preventing objective assessment of research quality), and funding adjudication (Cantini et al., 2019; Chiappa and Perez Mejias, 2019). In a region with great social and economic inequalities, with inequitable opportunities for higher education, this bias for internationalization could perpetuate or strengthen the advantages of higher social classes (Perez Mejias et al., 2018). Accordingly, some programs may consider merits and the socio-economic level of students but more data are needed to understand the impact of such solutions[8] (UN, Department of Economic and Social Affairs, 2020). While global experience is indeed an added value with inherent validity in terms of competitiveness and excellence, vigilance to practices in processes related to human capital management is advised. An *a priori* and subjective undervaluation of domestic education and training creates a vicious circle that threatens the quality of the same systems that are the focus of improvement. Also, an ultra-protective system benefiting national graduates, regardless of international competitiveness, is also a dangerous trend.

[8]Conversations on academic merit: https://www.acusafrica.com/post/cuppaconversation-the-limits-of-academic-merit-in-chile; Scholarships for developing countries: https://www.topuniversities.com/student-info/scholarships/international-scholarships-students-developing-countries

Moreover, reinsertion of ECRs who graduated abroad into their national systems as independent researchers can be complicated by bureaucratic and time-consuming recognition systems of studies abroad[9]. This threatens international or regional agreements that aim to increase international exchange and collaboration, a relevant situation considering that LAC is one of the regions with the poorest intra-regional mobility, with countries turning to the Global North[10]. Both unbalanced internationalism and national inbreeding can be detrimental to conducive research systems. A structured assessment system for the quality of research produced by ECRs-LAC could be designed and implemented to generate a more holistic view of research performance and its impact (**Table 1**).

Motivations for home country return are broad and hard to assess as isolated entities. These include scientific trends, national funding guidelines, personal circumstances, instability in host countries, or a combination of many. They have been analyzed in some LAC countries (Rivero, 2018; Rivero and Peña, 2020; Stehli, 2020). Often, the main motivation emanates from funding agreements to pursue training abroad that make return mandatory. Additional programs to support repatriation and insertion of highly skilled workers through funds for research and salary[11] (Arce Miyaki and Gomis Hernández, 2019) are key to fully harness the training pursued (**Table 1**). Unfortunately, oftentimes, ECRs-LAC do not have the equipment or infrastructure necessary for their research or their home institution does not hire them once a grant is completed[12] (Barañao, 2016). Consequently, a fourth mobility subgroup is created by researchers who returned home but, because of sociopolitical or economic reasons or lack of opportunities, decided to emigrate again.

HOW REGIONAL STRATEGIES COULD INCREASE COMPETITIVE RESEARCH IN THE LAC REGION

Irrespective of location, the scientific diaspora can actively contribute to knowledge development and exchange with their home country (Barré et al., 2003; Palacios-Callender and Roberts, 2018; Labrianidis et al., 2019) as their potential in science diplomacy and bilateral facilitation is a well-established notion (Burns, 2013; Wren, 2014). A well-connected diaspora may aid reinsertion strategies (Stehli, 2020) and help in designing national and regional graduate programs that could increase intraregional mobility, strengthening regional collaboration, and increasing productivity and visibility of research from ECRs-LAC (**Table 1**). ECRs-LAC could also pose as great science ambassadors for their countries, harnessing international connections and intermixing them in their home countries. LAC countries can actively integrate the diaspora in their science diplomacy strategies, create and strengthen scientific diaspora networks, and learn about successful cases from other countries (Gual Soler, 2020) (**Table 1**). Such concepts are already part of the science diplomacy approach of Spain (Elorza Moreno et al., 2017). In Latin America, successful examples of diaspora networks exist either as part of a ministerial framework (e.g., Argentina, Mexico) or as groups of independent networks (e.g., Chile)[13]. Similarly, ECRs-LAC, regardless of location, could play a role in science diplomacy and sustainable development of their country and region through government institutions and international and ECR organizations like the GYA and TWAS-TYAN. They can give a diverse perspective on ECR issues. Cross-disciplinary studies that focus on surveying the current landscape of ECRs-LAC are still needed to understand how regional scientific systems are supporting their careers (**Table 1**). Comparing with other regions can help discriminate general issues from specific regional ones and learn from best practices. Sub-regional associations built their research agendas based on common institutional guidelines that likely differ within LAC, originating disparities in reaching pan-regional goals[14]. The call to action is to identify the best strategies to solve roadblocks in the way of ECRs-LAC, so the region can benefit from their knowledge production. For each main challenge faced by ECRs-LAC, we suggest which essential actors should participate in the discussion to generate recommendations and ways forward to respond to these issues using data already generated or that need to be generated from multidisciplinary regional and national studies (**Table 1**).

OPENING THE DISCUSSION ON ECRS-LAC

Identification of ECRs-LAC concerns can be instrumental in the development of supportive policies for national scientific agendas. ECR networks and international organizations that include ECRs-LAC living in the region and the

[9]Future analyses could show the impact of the new Regional Convention On The Recognition Of Studies, Degrees And Diplomas In Higher Education In LAC: http://www.iesalc.unesco.org/2019/07/15/23-countries-adopted-the-new-regional-convention-on-the-recognition-of-studies-degrees-and-diplomas-in-higher-education-in-lac/
http://portal.unesco.org/es/ev.php-URL_ID=49523&URL_DO=DO_TOPIC&URL_SECTION=201.html.

[10]https://monitor.icef.com/2019/10/new-scheme-aims-to-boost-student-mobility-within-latin-america/.

[11]For example, Programa Inserción de becarios, SENACYT, Panama https://www.senacyt.gob.pa/wp-content/uploads/2017/02/PIB-2015-Reglamento.pdf
Programa Atracción e Inserción de Capital Humano Avanzado, CONICYT, Chile https://www.conicyt.cl/pai/sobre-pai/que-es-pai/.

[12]Pew Latin American Fellows, an example of a non-governmental program including repatriation funds: https://www.pewtrusts.org/en/research-and-analysis/fact-sheets/2014/10/a-ripple-effect-on-latin-american-science.

[13]Networks of Argentinean researchers abroad are institutionalized under the Ministry of Science, Technology and Innovation, and are intended to function as science diplomacy and policy actors: https://www.argentina.gob.ar/sites/default/files/if-2020-66820401-apn-spypctei-mct_anexo_iv_reglamento_del_sistema_de_redes_de_cientifico-as_argentino-as_en_el_exterior.pdf. An independent Mexican network was established with support of governmental agencies from Mexico https://www.redglobalmx.eu/. Redes Chilenas groups Chilean diaspora networks - mostly ECRs. Despite not being under an institutional framework, they have an impact on science policy https://redeschilenas.cl/.

[14]Subregional associations in LAC: Mercosur https://www.recyt.mercosur.int/ and CARICOM https://caricom.org/category/science-and-technology/.

diaspora should work together in designing studies to understand their particular challenges and to communicate them to relevant national and regional institutions. The diaspora can directly contribute to locally based ECRs on scientific collaboration and science diplomacy strategies that have a direct impact on the scientific progress in their home country.

While there have been efforts made to assess the status of ECRs-LAC, such as focusing on specific countries, disciplines, and aspects of their careers, a more holistic and systematic assessment is required. The GYA, in collaboration with other scientific academies like TWAS-TYAN, is undertaking this task as an ECR organization that is able to provide a voice to the diverse young researchers in the region. The study targets countries with different research profiles as a proxy of diverse LAC systems. Such evaluation in a regional and integrative approach will enable a combination of science diplomacy strategies and policies for a harmonized advancement of research in the region that could allow science-based sustainable development. This opinion article is based on currently available information on the topic and is an invitation to dialogue about ECRs in general and ECRs-LAC.

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All authors contributed to the bibliographical search, discussion, writing, and editing of the article.

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Science Diplomacy in Latin America and the Caribbean: Current Landscape, Challenges, and Future Perspectives

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Science, technology, and innovation are taking center stage in international affairs and increasingly influencing the geopolitical dynamics and a country's standing on the global stage. New scientific and technological advancements are acquiring greater strategic relevance to ensure competitive advantages in the twenty-first century global order. At the same time, international scientific collaboration contributes to generating and democratizing knowledge and improving relations between countries as a "soft power" tool to coordinate science-based solutions to transboundary problems, and to build bridges between countries with tense diplomatic relations. Science diplomacy is not a new concept, but most of its intellectual foundations and practical applications have emerged in the Global North. This article describes the diverse approaches, policies and practices adopted by Latin American and Caribbean countries at the national, sub-national, and regional levels. It analyzes their successes and challenges and identifies opportunities to guide the region toward a common science diplomacy strategy to achieve sustainable development through incorporating science as a permanent element in the foreign policy toolkit of Latin American nations. By documenting and illuminating best practices in the region, this article also seeks to balance the emphasis that has so far been largely concentrated on the regions of Europe and North America and contribute to future efforts and strategies for the development of sustainable science diplomacy mechanisms at the national, regional, North-South and South-South levels.

Keywords: science diplomacy, Latin America & Caribbean, South-South cooperation, science for peace, sustainable development goals, capacity building, foreign policy, global governance and multilateralism

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INTRODUCTION

Science diplomacy is gaining relevance as an essential tool to tackle global challenges that have a scientific dimension, do not respect national borders, and no country can solve alone (Ruffini, 2017). To reverse climate change, achieve sustainable development, provide food and clean energy to billions of people, restore biodiversity, and prevent and tackle global health crises such as the COVID-19 pandemic, greater coordination between the spheres of science and foreign affairs will be key (S4D4C, 2019). By aligning scientific and diplomatic agendas, nations can attract scientific talent, strengthen national research, and innovation systems and competitiveness, provide avenues for greater participation of scientists in the formulation of public policies, coordinate integrated solutions to common problems, and tend bridges between countries with tense or non-existent diplomatic relations (Quevedo, 2013; Gluckman et al., 2017).

The countries of Latin America and the Caribbean have a wide range of bilateral, regional, and global scientific cooperation instruments to strengthen and complement national research capacities (OEI, 2012), but science still plays a secondary role in policy in general and foreign policy in particular (Gual Soler, 2020a). Despite numerous multilateral initiatives "on paper," the region has failed to take full advantage of the opportunities and additional benefits that scientific collaboration offers to facilitate international relations, coordinate common actions in the face of transnational challenges, and achieve shared development objectives (Gual Soler, 2014). This article reviews the evolution and current landscape of science diplomacy, starting with a global outlook before focusing on Latin America and the Caribbean. The analyses and recommendations are informed by the author's own perspective after a decade of direct engagement as a policy advisor, researcher, lecturer, and trainer in science diplomacy across Latin American and Caribbean nations and institutions.

WHAT IS SCIENCE DIPLOMACY?

Throughout history, science has served as a meeting point to build alliances between countries under political tensions (Müller and Bona, 2018) in support of diplomatic agreements in areas of global health, biodiversity conservation, ocean governance, water resource management, nuclear non-proliferation, energy security or climate change, among many others. According to Costa Rican scientist Marino Protti Quesada (2018), *"there are areas of the planet, such as the open seas and deep ocean floors, the outer atmosphere and extraterrestrial space, which are used by many countries for their exploitation and for scientific research. These are fertile grounds for international conflicts, but also for the peaceful coexistence of nations if there are international treaties that regulate their use and guarantee peaceful coexistence."* Examples include the Antarctic Treaty of 1959 that dedicated Antarctica exclusively for peaceful scientific research, the Montreal Protocol of 1987 that achieved an unprecedented agreement between the scientific community, governments, and industry to eliminate the chemicals that damage the ozone layer, and the 2015 Paris Agreement that aligned 195 nations in a common goal to reverse climate change (Lewis et al., 2017; Paglia, 2021).

Despite this long tradition, the concept of science diplomacy and its applications began to gain traction well into the twenty-first century (Ruffini, 2020b). The term became popular after the Royal Society and the American Association for the Advancement of Science (AAAS) published in 2010 the first definition and theoretical framework for science diplomacy (The Royal Society & the American Association for the Advancement of Science, 2010). The report *"New Frontiers in Science Diplomacy"* organized science diplomacy in three main axes:

Science in Diplomacy refers to scientific support to foreign policy on bilateral and multilateral issues where science and technology are important, such as intergovernmental platforms on climate change and biodiversity, the management of shared natural resources and transboundary ecosystems, the coordinated management of global health treats, or the governance of global environmental commons such as Antarctica or the High Seas.

Diplomacy for Science refers to the diplomatic apparatus facilitating scientific collaboration between countries and promoting academic mobility and attraction of talent, knowledge, and innovations to improve the country's competitiveness. Diplomats pave the way for scientific cooperation at various levels, from the processing of visas and research permits for foreign students and researchers, to the negotiation of agreements and treaties for the construction and operation of large-scale scientific infrastructures, such as large telescopes or physics laboratories.

Science for Diplomacy refers to scientific cooperation as a soft power tool to improve international relations and establish communication channels between countries that are experiencing difficult relations in the political, economic, human rights, trade, or other spheres. In this case, international cooperation in science generates diplomatic benefits as well as advances in knowledge.

This initial conceptualization was largely predicated on the universality of science and its ability to cross borders and connect societies to address common challenges. This somewhat idealized vision has evolved over the years toward more pragmatic approaches, with the use of science, technology, and innovation at the bilateral and multilateral levels to meet both global goals and national interests (Ruffini, 2020b). In 2018, a group of scientific advisers to the foreign ministries of the United States, United Kingdom, Japan, and New Zealand proposed a new classification of science diplomacy actions based on the motivations of foreign ministries (Gluckman et al., 2017). These include improving a country's capacity for innovation and competitiveness through access to knowledge, markets, and technology abroad while attracting talent and investment; solving transboundary problems, such as the management of cross-border water resources; and addressing global challenges on a planetary scale, such as reducing carbon dioxide emissions or eliminating plastics in the ocean.

In the third decade of the twenty-first century, the strategic vision for science diplomacy is more and more oriented toward the commercial sphere, expanding its scope from the ministries of foreign affairs to cross-cutting strategies encompassing the ministries responsible for trade, education, environment, technology, health, or economy (Gluckman et al., 2017). Furthermore, science diplomacy is not limited to state actors or national governments: sub-national and supranational entities, the private sector, and civil society are becoming increasingly involved in its processes and activities (Melchor, 2020). Regardless of the approach, putting science diplomacy into practice requires new configurations and models of national, regional, and global collaboration between diplomatic institutions and the scientific community. To accomplish this, a myriad of actions are emerging that range from including scientific personnel in foreign ministries and embassies, exposing diplomats to science and technology issues and/or training scientists to communicate their science to decision makers, to the establishment of new institutions and professions dedicated to this matter.

WHO ARE THE SCIENCE DIPLOMACY ACTORS?

Given the complexity and speed of scientific and technological developments, many governments have recognized the need to understand the diplomatic implications of scientific innovations and incorporate science, technology and innovation into their foreign policy structures (Turekian and Kishi, 2017). In the last decade, ministries of foreign affairs, diplomatic services, international organizations, and universities have begun to coalesce into an ecosystem to align international cooperation in science with foreign policy objectives. The European S4D4C project[1] classifies the main players in the science diplomacy ecosystems as follows:

Governments are responsible for the design and implementation of national policy agendas and the coordination of scientific, environmental and health policies with foreign, development, defense, or trade policies. They involve ministries, embassies, research funding agencies as well as state and municipal governments. They establish bilateral and multilateral agreements for scientific cooperation with priority countries, articulate networks of scientists abroad, and appoint specialized functions to implement science diplomacy (Melchor, 2020). Two of the best characterized and institutionalized functions in science diplomacy are science attachés in embassies and diplomatic missions, and scientific advisers to foreign ministries, although there is considerable variation between countries in the background and recruitment mechanisms of these professionals. For example, science cooperation can be framed under the area of economic cooperation, or as part of cultural and academic affairs, depending on how a country's foreign service is organized. Some countries recruit academics who temporarily serve as scientific attachés, while others hire nationals of the country with local knowledge (Ittelson and Mauduit, 2019). The most common model of scientific advice in foreign ministries is the Chief Science Advisor, a direct advisor to the foreign minister who works alongside a multidisciplinary team of specialists in different fields of science and technology (Gluckman, 2016).

International organizations propose and raise transnational issues of a scientific nature and of global interest in the agendas of member states and generate science-policy interfaces to achieve multilateral solutions to common problems (Van Langenhove, 2016). They employ international civil servants, consultants, and advisors working at the science-diplomacy nexus interfaces. Examples include the United Nations System and other multilateral and supranational organizations such as the Organization for Economic Cooperation and Development, the African Union, the Inter-American Institute for Global Change Research, or the European Commission.

Academic sector: Universities, research centers, scientific-technical infrastructures, national academies of sciences, and scientific societies contribute knowledge toward solutions to national and global challenges and create spaces for dialogue and collaboration between scientists from different countries (Lyons et al., 2021). In some countries, academic experts contribute to diplomatic negotiations and are seconded to foreign ministries, development agencies, and embassies to serve as science counselors or attachés for a period of time and then return to their university positions[2].

Private sector: Companies seeking to access knowledge, technology, and innovation abroad often serve the agendas and interests of their home countries and promote services and products aligned with the country strategy and brand. Innovation diplomacy strategies are increasingly supporting the internationalization of startups and governments are setting up diplomatic representations to tech hubs in the face of the growing geopolitical importance of transnational technology companies and their critical role in the global governance of frontier technologies (Gual Soler, 2020a).

Civil society: A growing number of are NGOs, international networks, scientific associations, and private foundations specialize in building bridges between science, politics, and society. They elevate topics for national and international agendas and support science diplomacy through research, cooperation, training, and advisory programs and projects. For example, the AAAS Center for Science Diplomacy played a key role in establishing science diplomacy training programs around the world and promoting bilateral cooperation between scientists from the United States and Cuba, Iran, and North Korea amid long standing political tensions[3]. The International Network for Government Science Advice (INGSA) brings together science advisers to foreign policy to exchange experiences, successful models, and promote cooperation and training[4].

SCIENCE DIPLOMACY STRATEGIES AROUND THE WORLD

Science diplomacy is implemented through diverse instruments, including bilateral and multilateral research agreements, collaboration networks, representations abroad, training programs, and in general any activity that involves science and foreign policy actors (Flink and Schreiterer, 2010). In several countries, a strong commitment to science diplomacy led to the redesign of certain structures of their Ministries of Foreign Affairs.

For example Denmark was a pioneer of *techplomacy* with the appointment of the first ambassador to Silicon Valley to promote digital diplomacy with high-tech companies as a priority for foreign policy, as well as raising awareness of the risks of disruptive technologies and digital divides[5]. This model gained traction quickly among other nations such as France or Germany. In 2016 Spain launched its Strategy for Science, Technology and Innovation Diplomacy jointly promoted from the Ministry of Science and Innovation and the Ministry of Foreign Affairs (Gobierno de España, 2016). Its objectives range from organizing the scientific diaspora, promoting Spanish scientific and technological advances abroad,

[1] www.s4d4c.eu

[2] https://sites.nationalacademies.org/PGA/Jefferson/index.htm.

[3] https://www.aaas.org/program/center-science-diplomacy/engagemen

[4] https://www.ingsa.org/divisions/spider/

[5] https://techamb.um.dk/en/techplomacy

and introducing scientific training in the diplomatic academy. Scientific coordinators and science diplomacy interns were installed in key embassies such as London, Berlin, and Washington. France created a Department of Global Affairs in the Ministry of Foreign Affairs that includes an office for scientific mobility and attraction policies, with a network of hundreds of science attachés and volunteers deployed in the French representations abroad to link them with French research institutes, companies and centers of competitiveness[6]. Similarly, Japan deployed specialized science and technology officials to more than 20 representations abroad with the aim of expanding access to resources for research outside its borders. The United Kingdom approaches science diplomacy for international economic positioning and increasing its soft power in new countries through a Science and Innovation Network of 90 officers in 28 countries and 47 cities through its network of embassies and consulates[7]. Switzerland articulates the Swissnex network to link innovation hubs with the science and technology offices of the Swiss embassies to strengthen Switzerland's profile as a partner[8] has recently appointed a Special Envoy for Science Diplomacy[9]. A similar posting was created in the Czech Republic[10]. The Netherlands launched a specific fund for scientific cooperation with countries with which it seeks to strengthen its diplomatic relations[11].

Beyond this mosaic of national approaches, supranational and subnational strategies are on the rise. The European Union gave a high profile to science diplomacy in 2015 (Moedas, 2016) and in 2020, the European External Action Service (EEAS), the foreign policy arm of the European Union, appointed its first science advisor. At the state, region, and province levels, there are science and innovation diplomacy strategies in São Paulo in Brazil[12], Quebec in Canada[13], and Wallonia in Belgium, and at the city level in Geneva, Barcelona, Boston, New York, Shanghai, and Mexico City (Roig, 2019). Some of these cities have created 'science and technology diplomacy circles' that bring together those responsible for science, technology, and innovation from diplomatic missions and international organizations both in capitals and in innovation hubs[14]. This is turning cities into geopolitical actors, serving as laboratories of innovation through scientific, technological, and cultural exchange and driven by innovative public-private partnerships.

[6]https://www.diplomatie.gouv.fr/en/french-foreign-policy/scientific-diplomacy/
[7]https://www.gov.uk/world/organisations/uk-science-and-innovation-network
[8]https://swissnex.org/
[9]https://www.eda.admin.ch/eda/en/fdfa/fdfa/aktuell/newsuebersicht/2021/02/science-diplomacy.html
[10]https://www.mzv.cz/jnp/en/foreign_relations/science_and_technology/index.html
[11]https://www.nwo.nl/en/news-and-events/news/2020/05/first-activities-awarded-in-science-diplomacy-fund.html
[12]https://2019.innscidsp.com/sao-paulo-framework-of-innovation-diplomacy (2019)
[13]http://www.scientifique-en-chef.gouv.qc.ca/en/dossiers/diplomatie-scientifique/stages-scientifiques-dans-les-representations-du-quebec-a-letranger/
[14]http://stdc-boston.com/

THE SCIENCE DIPLOMACY LANDSCAPE IN LATIN AMERICA AND THE CARIBBEAN

The debate on science diplomacy and its applications has been developed mainly in English, dominated by North America, Europe, Japan, or New Zealand (Turchetti et al., 2020) and therefore the resources in Spanish on this concept are still limited. The countries of Latin America and the Caribbean have a wide range of bilateral, regional, and global scientific cooperation instruments to strengthen and complement national research capacities (OEI, 2012). However, despite numerous multilateral initiatives, the region has not been able to take full advantage of the opportunities and additional benefits that scientific collaboration offers to facilitate international relations, coordinate common actions in the face of transnational challenges, and achieve collective sustainable development goals. Political instability, ideological fragmentation, budget problems, and the multiplicity and redundancy of high-level forums with different memberships and configurations, each with its own science and technology commission[15], have limited the effectiveness and relevance of multilateral scientific initiatives.

But in 2015, the UNESCO Regional Office of Science for Latin America and the Caribbean introduced science diplomacy in its agenda for sustainable development[16]. Since then, science diplomacy has risen on the agendas of several Latin American countries and multilateral organizations, and has been promoted in high-level regional training and dialogues. Argentina, Brazil, Chile, Costa Rica, Cuba, Mexico, and Panama are some of the countries that have started, reinforced and labeled their activities the science-foreign policy interface as "science diplomacy" actions, adopting diverse strategies to incorporate science, technology and innovation into their foreign policy structures (Gual Soler, 2020b). These were highlighted recently at the 2021 edition of the Latin American Open Science Forum (Foro CILAC) promoted by UNESCO (de Ambrosio, 2020).

National Approaches

Panama, Colombia, and Costa Rica are taking steps to institutionalize their science diplomacy strategies within the science and foreign ministries. In 2018 Panama became the first Latin American nation to define a national strategy. The "Strategy of scientific, technological and innovation diplomacy as an instrument of 21st century diplomacy,"[17] jointly promoted by the Ministry of Foreign Affairs and the National Secretariat for Science, Technology, and Innovation, sought to leverage Panama's strategic location as a connecting hub in the Americas, its world-class tropical biodiversity and expertise in tropical medicine, and set out to equip Panamanian diplomats with

[15]Such as the Organization of American States (OAS), the Community of Latin American and Caribbean States (CELAC), the Union of South American Nations (Unasur), the Organization of Ibero-American States for Education, Science and Culture (OEI), Mercosur or the Central American Integration System (SICA).
[16]http://www.unesco.org/new/es/media-services/single-view/news/science_and_diplomacy_at_the_center_of_debate_for_sustainabl/
[17]https://mire.gob.pa/images/PDF/Lineamientos%20de%20la%20Estrategia%20de%20Diplomacia%20Cientifica%20-%20Rev%2031%20de%20mayo%20de%202019.pdf

knowledge in science, technology, and innovation to align Panama's foreign policy with the UN Sustainable Development Goals. In 2021, science diplomacy will be incorporated in the new Science Law, paving the way for the strengthening of scientific advice at both the domestic and international levels (Gittens et al., 2021).

With the creation of the new Ministry of Science, Technology, and Innovation in 2020, Colombia is in the process of creating a national science diplomacy strategy, which proposes the creation of 9 nodes in strategic countries (including border areas with Brazil, Panama, and Peru), a greater articulation between the scientific diaspora and the Colombian scientific and academic communities with international networks, and capacity building in science diplomacy, both within the government and in other entities and actors[18]. The positioning of Colombia in South-South cooperation scenarios is also part of the strategy, taking into account its new role in the region and its potential to support countries with fewer capacities after its entry into the OECD in April 2020[19].

Costa Rica has long been a leader in climate negotiations from the 1992 Earth Summit to the 2015 Paris Agreement, whose architect was the Costa Rican diplomat Christiana Figueres. In 2014 Costa Rica appointed for the first time a scientist as ambassador to the United States, who launched an ambitious bilateral scientific cooperation agenda in the areas of water, public health, disaster prevention, and remote sensing. Costa Rica also promotes the peaceful application of technology related to disarmament and international security, including the peaceful uses of nuclear energy, security in space and cyberspace, and the use of new technologies such as artificial intelligence at the service of peace and sustainable development[20]. In 2019 the Ministry of Foreign Affairs, through its Manuel María de Peralta Foreign Service Institute and the National Academy of Sciences of Costa Rica (ANC), began institutional efforts to link diplomats with researchers, and in 2020 initiated the formal structuring of a science diplomacy strategy under the Economic Diplomacy Process (López-Vergès et al., 2021).

However, not all efforts that fall under the science diplomacy umbrella are labeled as such, which complicates their analysis and categorization (da Silva et al., 2021). For example, Brazil and Chile have well-established science cooperation departments within the foreign ministry that only recently started using the terminology. In Brazil, the Department of Science and Technology in the Ministry of Foreign Affairs has an Innovation Diplomacy Program implemented both at the federal and subnational level from the state of São Paulo[21]. Chile has a Directorate of Energy, Science and Technology and Innovation in the Ministry of Foreign Affairs which seeks to link Chile's policies in energy, science, technology, and innovation with foreign policy through strategic alliances with key countries, international organizations and other relevant actors for strengthening and complementing national capacities in these areas[22]. It's worth noting that only Brazil and Chile have formalized the figure of science attaché in their embassies, and to date no Latin American country has fully institutionalized the figure of scientific advisor to the Ministry of Foreign Affairs, although there are variations such as the appointment of an Ambassador for Science, Technology, and Innovation in Bolivia[23] and the opening of Uruguay's first technology consulate in San Francisco, USA[24].

In the "science for diplomacy" dimension, Argentina and Cuba are good examples of using science to build diplomatic relations or to ease tensions in other areas. Argentina has managed to forge fruitful scientific cooperation with the United Kingdom despite the complicated diplomatic relations of the last decades over the Malvinas/Falkland Islands in areas like agri-technology, advanced materials and nanotechnology, ICT, life sciences, marine science, and palaeontology (Grimes, 2018). International scientific cooperation has also contributed to the consolidation of long standing interactions that can overcome the gaps associated with changes in the national government. For example, it is a usual practice by Argentine ambassadors to start with a scientific mission after they arrive at a new destination because it is usually an area devoid of potential conflicts (Barañao, 2016). Cuba is one of the countries with the longest tradition in scientific and medical diplomacy in the region, based on its advanced biotechnology industry and a robust health system[25]. Since 1963 the country has sent more than 400,000 medical professionals in 164 missions to countries in Africa, America, the Middle East, and Asia, in addition to providing humanitarian aid in cases of catastrophes, emergencies, and epidemics such as Ebola and more recently COVID- 19. This has allowed Cuba to gain international prestige and political capital, reflected for example in the votes against the United States embargo in the UN General Assembly (Malacalza, 2016). The Cuban Academy of Sciences has been instrumental in facilitating scientific cooperation between Cuba and the United States on issues of common interest such as hurricanes and infectious diseases, due to the lack of official diplomatic channels during various periods of relations between the two countries. The sustained cooperation between the Cuban Academy of Sciences and non-governmental scientific institutions such as AAAS and the US National Academy of Sciences paved the way for the reopening of diplomatic relations in 2015 (Pastrana et al., 2018).

A growing trend is the orientation of science diplomacy toward strategic sovereignty in the space, energy, nuclear or maritime spheres. For example, the Pampa Azul initiative in Argentina articulates the work of seven ministries, including

[18]Equipo de internacionalización del Ministerio de Ciencia, Tecnología e Innovación de Colombia (Personal communication).

[19]https://www.oecd.org/newsroom/global-oecd-welcomes-colombia-as-its-37th-member.htm

[20]Ministerio de Relaciones Exteriores y Culto de Costa Rica. Personal communication.

[21]http://antigo.mctic.gov.br/mctic/opencms/institucional/Cooperacao_Internacional/Diplomacia-e-Inovacao-Cientifica-e-Tecnologica.html?searchRef=nanosseguran%C3%A7a&tipoBusca=expressaoExata

[22]https://minrel.gob.cl/politica-exterior/secretaria-general-de-politica-exterior/decyti

[23]https://comunicacion.gob.bo/?q=20200213/28796

[24]https://www.uruguayxxi.gub.uy/en/news/article/uruguay-inaugura-en-san-francisco-su-primer-consulado-tecnologico/

[25]https://www.coha.org/cuban-medical-diplomacy-when-the-left-has-got-it-right/

science and foreign relations focused on the Argentinian Sea[26]. Recently, Argentina and Mexico agreed to lead the creation of a Latin America Space Agency[27]. Thanks to its privileged geographical position for astronomical observation and access to Antarctica, Chile bases a significant part of its strategy on attracting large international research projects in "natural laboratories" in the Andes and the Chilean Antarctic bases. And a recent proposal aims to create the ANDES Lab, an underground binational physics laboratory between Chile and Argentina with a model similar to the European CERN[28].

In recent years, Ecuador, Peru, and Uruguay have also begun promoting international research collaborations and mobility to enhance their visibility in the global stage and access economic, human and material resources not available domestically (Belli and Baltà, 2019).

Other initiatives in progress in the region include the launch of a scientific, technological, and business innovation diplomacy program in the Dominican Republic[29].

Regional Approaches

At the regional and bi-regional levels, two instruments of note are the Ibero-American Program for Science and Technology for Development (CYTED) and the Inter-American Institute for Global Change Research (IAI). Both programs, born as North-South scientific collaboration networks promoted by Northern countries, Spain, and the United States, evolved into more horizontal South-South cooperation schemes and have contributed to the regional integration of Latin America, creating spaces for the incorporation of science in public policy, decision-making, and governance, resulting in greater regional cohesion and harmonization of science policy mechanisms (Gual Soler, 2014).

The Latin America Open Science Forum (Foro CILAC) promoted by UNESCO is a bi-annual event rotating different cities across the region for dialogue and regional cooperation to devise a common horizon in science, technology, and innovation for Latin American countries to achieve the 2030 Agenda[30]. Science diplomacy has been a central theme in both high-level sessions and training workshops since the launch of CILAC in 2016, and a policy brief dedicated to science diplomacy in Latin America and the Caribbean was launched at Foro CILAC 2021 (Gual Soler, 2020b).

Education and Training in Science Diplomacy

Most of the national and regional science diplomacy strategies described in this article include a training component to foster the new types of professionals capable of navigating the science-diplomacy nexus. The Diplomatic Academy of Chile Andrés Bello launched in 2019 a science diplomacy training track to promote the insertion of Chile in international research and innovation networks[31]. Argentina, Panama, and Mexico have also recently incorporated science, technology, and innovation modules into their diplomatic training (Gual Soler, 2020b). An important element of the Panamanian strategy was to incentivize the recruitment of STEM professionals to diplomatic careers, updating the rules and requirements for entry into the foreign service to accept graduates from any background[32].

In the last decade, several international initiatives have emerged to formalize educational and curricular structures for the training of specialists in this interface. For example, The World Academy of Sciences (TWAS), in collaboration with AAAS, has offered since 2014 a landmark course in science diplomacy at its headquarters in Trieste, Italy, which has trained over 300 young scientists and diplomats from the Global South, Although fewer trainees from Latin America have attended these trainings, in comparison to other regions[33], they have had an outsized impact in advancing science diplomacy in their countries (Gittens and Lopez-Verges, 2018; Gittens et al., 2021). Other organizations offering science diplomacy training include INGSA, the IAI, the United Nations Institute for Training and Research (UNITAR), and the Horizon-2020 funded EU Science Diplomacy Cluster[34].

Training models and formats range from short intensive courses and workshops to exchange programs of several days or weeks between scientists and diplomats, typically including role-play diplomatic simulations and science-intensive negotiation exercises, case studies, and networking activities[35]. But beyond *ad-hoc* training and workshops, to train professionals in science diplomacy and prepare both communities to work with one another, the most effective approaches are experiential learning programs and mainstreaming science diplomacy in university curricula (Mauduit and Gual Soler, 2020).

For example, countries in North America and Europe offer scholarships, internships, and pairing schemes that provide immersive experiences for scientists in governments, embassies, and international organizations during their graduate or postdoctoral work to gain experience in a government or parliamentary office (Gual Soler et al., 2017). The IAI has recently launched the first program of this kind, a pilot Science, Technology, and Public Policy Fellowship (SteP) with fellows from Argentina, Mexico, Canada, and the US[36], Fellows spend a year immersed in a policy setting to facilitate the incorporation of scientific knowledge into policy processes relevant to global environmental change and obtain professional development in science diplomacy, science advice, and science communication to

[26]https://www.pagina12.com.ar/276817-el-relanzamiento-de-pampa-azul-una-iniciativa-que-articula-e
[27]https://elpais.com/mexico/2020-11-21/alce-el-sueno-de-la-conquista-latinoamericana-del-espacio.html
[28]http://andeslab.org
[29]https://aduanasdigital.gob.do/2020/02/04/cancilleria-lanza-diplomacia-cientifica-tecnologica-e-innovacion-empresarial/
[30]http://www.forocilac.org
[31]http://www.academiadiplomatica.cl/index.php/academia-diplomatica-de-chile-potencia-la-diplomacia-cientifica/
[32]Decreto Ley 60 (2015). Decreto Ley 60, Pub. L. No. Ley 60, Rollo 620, Posición 698, artículo 3, Derecho Administrativo, Que Modifica y Adiciona Artículos a la Ley 28 de 1999, Sobre la Carrera Diplomática y Consular; Panamá
[33]https://twas.org/article/mainstreaming-science-diplomacy-global-south
[34]www.science-diplomacy.eu
[35]https://www.aaas.org/news/future-science-diplomats-receive-range-training-aaas
[36]http://www.iai.int/es/step

learn to integrate diverse knowledge and experience in different sectors and countries in response to the critical challenges of global change in the Americas.

An important development in recent years has been the introduction of science diplomacy curricula at Latin American universities. In 2019, the University of São Paulo in Brazil established the São Paulo School on Science and Innovation Diplomacy[37]. In 2020, the Universidad Externado de Colombia included a science diplomacy module in the "New Diplomacies" course, and the National Autonomous University of Mexico (UNAM) launched a science diplomacy course in the International Relations undergraduate program. Argentina has invested in international research and training programs for Latin American scientists to strengthen regional integration by creating environments in which young scientists can establish personal bonds that can lead to future scientific cooperation at a regional level, while promoting a sense of social responsibility that is not usually emphasized in the scientific centers of excellence in the Global North (Barañao, 2016). Similarly, Cuba contributes to training human resources in Latin America through international and regional schools in various disciplines from public health to climate resilience[38].

CHALLENGES AND BARRIERS

As science, technology, and innovation take on a growing value in world diplomacy, it will be necessary to create more spaces for collaboration between both worlds. A key challenge is that most of the intellectual foundations, practical applications, and case studies of science diplomacy have emerged from the Global North. Although there are successful and replicable models, each country must build its own structures adapted to the government system and the (geo)political, economic, social and scientific context. In addition, science diplomacy remains a fluid concept, understood differently by different stakeholders, and can be explicit or implicit[39]—that is, many activities, policies, programs, and instruments can be considered science diplomacy actions without the label, making them difficult to systematize, institutionalize, and operationalize (Turchetti and Lalli, 2020).

Latin America is one of the most unequal regions in the world (CEPAL, 2016)[40]. where societies face different moments in their development stage, some with very low investment in research, with the exception of Brazil[41]. Despite many Latin American countries having sophisticated STI policy instruments in place and strong growth in higher education, human resources development, and scientific production in recent years (UNESCO Science Report: Towards 2030, 2015), an absence of a tradition of evidence-based decision-making is still pervasive. It is common for the foreign ministry and the science ministry (if the country has one) to rarely interact, complicating the alignment between science policy and foreign policy. From a governance perspective, most Latin American diplomatic institutions were founded in the nineteenth century, while the institutionalization of science began in the second half of the twentieth century. But on the other hand, the region harbors a growing policy interest in indigenous knowledge and is stepping up investment in sustainability-related sciences. For example, the share of scientific articles focusing on indigenous knowledge has grown in all Latin American countries and is much higher in countries like Bolivia, Colombia, Guatemala, and Nicaragua than in developed countries (UNESCO Science Report: Towards 2030, 2015).

Another challenge is that it is common to appoint political appointees in diplomatic posts, often from the business sector (Acosta, 2006), which further complicates access from non-traditional backgrounds (e.g., STEM) to careers in foreign affairs. Connecting science and diplomacy requires a reconfiguration of the learning and professional development pathways of both communities and the participation of professionals who perform a variety of functions that often do not fit with traditional careers in science or international relations, as the necessary knowledge, skills, and capacities of its professionals are not yet fully defined and are highly context-dependent (Mauduit and Gual Soler, 2020). Furthermore, most countries outside the Global North lack non-governmental institutions that can act as a bridge between government and academia. These are usually best placed to advance science diplomacy and act as neutral intermediaries, especially between countries that do not have official diplomatic relations (Bednarek et al., 2018).

In countries with institutionalized science diplomacy such as the United States or the United Kingdom, many professionals with scientific training, most of them with PhDs, occupy full-time positions in the foreign ministry or embassies (Gual Soler et al., 2017). This model is problematic in the Latin American context, where many countries have an insufficient number of researchers (only 3.6% of global researchers)[42], so those who stand out are constantly invited to form part of expert committees from various areas of government (Gittens and Lopez-Verges, 2018), complicating both their daily practice as researchers, as well as their understanding of the complexity of policy and diplomacy processes. Many Latin American countries also face have legal or bureaucratic barriers to entering the diplomatic career from a science, technology, or engineering background, in addition to cultural barriers, lack of awareness among graduates about the range of professional options available, and resistance from academia to the idea that a scientist can work in other sectors.

[37] https://2020.innscidsp.com/

[38] https://www.cubahora.cu/ciencia-y-tecnologia/ciencia-cubana-desarrollo-y-cooperacion

[39] This article only considers explicit science diplomacy actions, as defined by Van Langenhove (2016) in https://www.ies.be/files/Tools%20for%20an%20EU%20Science%20Diplomacy_by%20LukVanLangenhove.pdf

[40] https://www.cepal.org/es/comunicados/cepal-pese-avances-recientes-america-latina-sigue-siendo-la-region-mas-desigual-mundo

[41] Other than Brazil, no country in Latin America spends more than 1% of GDP on research and development https://en.unesco.org/sites/default/files/usr_7-7_gerd_lac_en.pdf

[42] https://en.unesco.org/sites/default/files/latin_americas_place_in_the_world_usr15.pdf

SEVEN STEPS TO STRENGTHEN SCIENCE DIPLOMACY IN LATIN AMERICA AND THE CARIBBEAN

Globalization is reconfiguring traditional geographic and geopolitical boundaries. The transnational nature of the most complex problems requires international dialogues between multiple actors from different countries and regions at all levels of government—local, state, national, and supranational. Although the Latin American region suffers from deep inequalities, its countries, unlike other more heterogeneous regions such as Africa or Asia, share cultural, linguistic, historical, and religious traditions, which is an advantage for regional integration in the face of shared challenges such as endemic diseases or vulnerability to climate change (Barañao, 2016). The examples shown here indicate that science diplomacy is experiencing a surge in popularity in the Latin American region, but the greatest challenge will be to build sustained bridges between actors, policies, and functions that can survive political cycles. Seven steps can help the region advance toward stronger regional coordination structures in science diplomacy.

First, science diplomacy should be introduced as an interdisciplinary field of study and research in Latin American universities in both science and international relations programs, as well as including it as a fundamental pillar for the external projection of academic institutions[43]. All science and technology students should receive communication, negotiation and leadership tools, interpersonal and intercultural skills, and knowledge of global policy issues. Establishing the figure of *Diplomat in Residence* in universities, common in US higher education, can provide guidance and advice on science diplomacy careers to the academic community[44].

Second, governments should create scholarship programs, internships, and exchange schemes between researchers, public officials and diplomats, and articulate networks of scientists abroad to strengthen national scientific systems and promote "brain circulation." They should also establish regular interministerial commissions for science diplomacy to foster direct communication between foreign ministries, ministries of science, trade, environment, energy and other actors, including non-governmental entities, to align science policy with foreign policy in a whole-of-government approach[45].

Third, foreign services need structural, institutional, and educational changes, including promoting access to the diplomatic career and public service of professionals with training in science, technology, engineering and mathematics, introduce modules on science and technology in diplomatic training, establish permanent scientific advisory structures in ministries of foreign affairs, and creating the figures of science attaché in diplomatic missions and international organizations. These can include not only national governments, but sub-national entities such as city and regional governments.

Fourth, regional organizations must review and find synergies between spaces and commissions dedicated to scientific cooperation in the different regional and subregional forums to avoid multiplicities and redundancies.

Fifth, strengthening the role of the private sector, until now largely absent in science diplomacy spaces, as businesses are key drivers of the necessary transformations toward the Sustainable Development Goals (e.g., technology for education and communication, artificial intelligence, clean energy).

Sixth, new hybrid institutions should be created outside governments and academia at the national and regional level tasked with raising awareness, networking and training of different actors on science diplomacy issues, including close collaboration with science journalists and the media to contextualize science diplomacy to the Latin American reality and transmit its value to society.

Finally, all these efforts should converge in a regional network that articulates ministries, diplomatic academies, research agencies, universities, academies of science and other relevant entities to set a common agenda, exchange experiences, strengthen capacities, and coordinate actions, as well as connect with other international science diplomacy networks.

Cultivating better relations between the scientific and foreign policy arenas is an imperative for Latin America and Caribbean nations and institutions to ensure that science, technology, and innovation are engines of sustainable development and the region is more resilient to future crises[46]. Only by breaking the silos between governments, universities, the private sector and civil society will science, health, and the environment become true global public goods to achieve the 2030 Agenda.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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[43]https://www.fecyt.es/es/noticia/recomendaciones-para-la-diplomacia-cientifica-en-america-latina-y-el-caribe

[44]https://careers.state.gov/connect/dir/

[45]https://gesda.global/wp-content/uploads/2020/11/GESDA-SAB-9_Future-of-Science-Diplomacy.pdf

[46]https://www.scidev.net/america-latina/news/uruguay-y-covid-19-la-ciencia-al-servicio-de-la-poltica/

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Participation in Communities of Women Scientists in Central America: Implications From the Science Diplomacy Perspective

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The experience of building and participating in women scientists' communities in Central America is a multi-layered topic worthy of study. Understanding the dynamics of these women's groups, associations, and other forms of collective participation, could assist in shedding light on why women are typically under-represented in Science, Technology, Engineering, and Mathematics (STEM) research in countries within this region. The objectives of this study are (i) to explore the experiences of participation in communities of women scientists in Guatemala, El Salvador, Honduras and Panama, and (ii) to systematize the challenges and opportunities derived from such activities. Additionally, this work elaborates on some best practices from the Science Diplomacy (SD) perspective, which could provide a helpful framework to encourage these types of collective participatory communities. The qualitative research methodology was based on the collection of primary data from semi-structured interviews and responses to an online survey sent out to Central American women scientists. The findings of this study revealed few cases of community building experiences among women scientists within the studied countries. Evidence also showed the emergence of shared patterns in terms of barriers and disincentives to participating in such communities. Meanwhile, data collected from the few existing community groups is used to identify successful incentives and motivations. The analysis of the collected data offered relevant implications for Science Diplomacy. Most respondents referred to the Organization of Women in Science for the Developing World (OWSD) as one of the main organizations that can impact and further Science Diplomacy. This organization promotes international engagement and networking among women scientists from developing countries across regions and this article shows how this has been used to foster women science community building in Central America. Exploring similar practices in-depth may offer opportunities to overcome traditional barriers and build further gender equality in science in Central America.

Keywords: women research communities, women in STEM, science diplomacy, Central America, Latin America, scientific diaspora, OWSD, women science networks

INTRODUCTION

Central America represents an ideal geographical locus for examining the building of women scientists' communities, as well as, the dynamics of participation within those groups. Guatemala, El Salvador, Honduras and Nicaragua have been categorized as scientifically lagging countries (Wagner et al., 2001; IDB Inter-American Development Bank, 2010; TWAS, 2020). All these countries, including Costa Rica and Panamá, have recorded inadequate research capacity (Padilla-Perez and Gaudin, 2014), when compared with global accepted standards. At a historic moment in which knowledge economies are ever-more powerful, these societies struggle to allocate the critically needed resources to build science and technology capabilities. Pressing problems such as acute poverty, structural inequality, political instability, and precarious access to basic services such as health and education, require the immediate attention of leaders and inevitably science and technology are relegated to a marginal position on the public agenda. In this context, the participation of women in research and scientific activities has been restricted by structural barriers which have diminished their ability to access career opportunities in STEM; furthermore, the possibilities for engaging in community building and participation are limited. In this context, since 1993 OWSD has provided a platform for networking and community building for women scientists living within developing countries, as well as those nationals from such countries but residing abroad (OWSD, 2020; Quadrio-Curzio et al., 2020). Reaching out to the scientific female diaspora has been a key feature of this networking, together with encouraged exchanges and collaborative processes among women from different parts of the world.

Regions such as Africa, the Middle East and South Asia have shown important progress with growing membership and active organization in the form of National Chapters. However, Latin America has made advances at a slower pace. This has been made more evident in the case of Central American countries; despite the 27 years that OWSD had been encouraging membership and participation in multiple activities, no national chapters were established within Central American countries until 2020. However, in just one year, Guatemala and Honduras national chapters were established, and El Salvador and Panamá began engaging in the process. With this in mind, it is evident that exploring the experiences of participation in communities of women in science in Central America may provide insights for other marginalized scientific groups. A National Chapter of OWSD consists in a community organized by women scientists national of a given country from the developing world (including those living within the territory or abroad) with the objective of promoting women's participation in science and technology, scientific leadership, and scientific decision-making, both at the national and regional levels (OWSD, 2020). The processes for establishment requires a minimum of 20 members with the existence of a local host institution. Once an OWSD National Chapter is established, its members "carry out strategic activities according to priorities they identify within their own countries, including outreach to schools and the public" (Quadrio-Curzio et al., 2020:6) and also, focused in seeking career opportunities in benefit of its members.

Community building and community participation, for the purpose of this study, are understood as the various schemes in which women in science participate with a sense of group belonging with shared interests related to their research activities. These groups may be formal and institutionalized (i.e., science academies, associations, foundations, and NGOs) as well as informal groups (i.e., online platforms, collaborative groups, and discipline/subject-oriented networks). Nonetheless, a systematic and structured participation is required, which leaves out episodic group formations, such as those organized around a particular event or social group, that fades away once the purpose of their creation is achieved. The reviewed literature reports that most such scientific societies in Guatemala, El Salvador, Honduras and Panamá are male-oriented (Calles-Minero, 2010; WEF, 2020). Socially assigned roles and institutional gender-based biased have resulted a concentration of research STEM-related career opportunities for men. In consequence, those fields are considered unsuitable for women in the social context (IDB Inter-American Development Bank, 2010; Calles-Minero, 2013; Fernandez-Poluch et al., 2016). Moreover, the absence of specific policies and practices addressing gender inequalities in science and the representation of women in decision-making positions, as well as, insufficient efforts to create networks among female scholars and researchers have resulted in decades of isolated and insufficient women scientific community building experiences.

In this study, the researchers explored the possible root-cause for such outcomes, considering barriers and obstacles at individual, institutional, economic and societal levels through the collection and analysis of primary and secondary qualitative data. The incentives and disincentives experienced in Central America by women scientists in building and participating in science-related communities are highlighted. The conceptual frame offered by SD provides a special focus on the synergies presented by international engagement and the implications of such cross border exposure to enable community building among female researchers.

PARTICIPATION OF WOMEN SCIENTISTS IN COMMUNITY BUILDING FROM THE SCIENCE DIPLOMACY PERSPECTIVE

Central American countries have relied for several decades on international support to construct their science and technology capacities (Bonilla and Kwak, 2014; Bonilla and Kwak, 2015; Bonilla et al., 2019), in this context SD studies may provide a helpful background to analyze science and technology relevant issues, such as the one covered in this research. SD is understood as a series of practices at the intersection of science, innovation and technology, and foreign policy to address common international issues (The Madrid Declaration on Science Diplomacy, 2019) and it aims at fostering international scientific collaborations among nations to address common problems, and to build constructive international partnerships.

These practices can help to address global challenges, promote understanding, and increase influence and prosperity. In this view, scientific networks play an important role as a vehicle for sustainable development, cohesion and international relations (Fedoroff, 2009; Linkov et al., 2016; Balakrishnan, 2018; Mauduit and Gual-Soler, 2020).

Balakrishnan (2018), explains that SD can usefully be applied to the role of science, technology and innovation in three dimensions: 1) Scientific advice and inputs into foreign policy making (science in diplomacy) 2) Promoting international science cooperation (diplomacy for science), and 3) Using science cooperation to improve relations between countries (science for diplomacy). The second dimension of this proposed framework provides scope to this analysis as it focuses mainly on the facilitation of international scientific collaborations and the overall goal is to benefit from international science and technology resources in order to improve the national capacity; also, to build up joint partnership projects. (Melchor et al., 2020). Van Langenhove (2016) states that one of the components of SD, regards when groups are organized not only in disciplinary and epistemic communities but also in advocacy networks. SD is interdisciplinary and closely involved in bridging the gap between scientific workforce and diplomacy. Rhoten and Pfirman (2007) describe that the interdisciplinary nature of scientific networks may present junior women in science with valuable tools to overcome the structural and cultural obstacles of mainstream androcentric science. They also suggest that women are well positioned to make major advances in interdisciplinary research as they may integrate across fields and approaches, team-orientations, and be committed to connecting their research with societal concerns. The scientific debate on gender aspects in research systems has focused primarily on the overrepresentation of male academics, the productivity gap and issues of gender discrimination (Araujo et al., 2017). Furthermore, Rhoten and Pfirman (2007) state that the isolation of women is presently still problematic due to the historic overrepresentation of men in academic institutes, which constantly promotes the masculine culture. This asymmetry correction involves a complete stakeholder engagement process, including government support to create spaces and foster the participation of women in specialized communities that focus on specific aspects of collaboration. According to OWSD when women are included as both participants in scientific research and as beneficiaries of scientific research the impact on children, elderly and local communities will be directly positive and highly effective (OWSD, 2020). However, the global emergence of the COVID pandemic has delayed and even produced setbacks in the reduction of gender imbalances. While researchers might have harnessed improvements in telecommuting during the lockdown periods to focus on data analysis and publication writing, the gender bias intensified (Lopez-Verges et al., 2021; Ribarovska, et al., 2021).

It is well known that scientific research can lead to research outputs that could potentially solve many problems faced by developing countries. Although their scientific contexts still deal with diverse challenges, including the insufficient participation of women. The National Research Council (2012) states that one of the main challenges in the promotion of gender equity in science is the lack of a unified voice to speak on behalf of women's specific needs to use science and effectively communicate with broader sectors of society. As for the link between gender, community participation and science diplomacy, a recent growing awareness has been raised in the literature (Cohen Miller et al., 2020; Quadrio-Curzio et al., 2020; Sharma et al., 2020), including the significance of inclusiveness and networking as principles for SD (Aukes et al., 2021) and the observation of a collaborative bottom-up approach (Moreno et al., 2017). At the regional level UNESCO (2020) recommends creating transnational scientific networks in order to strengthen the national system in less developed S&I contexts and foster "brain circulation." In the same sense, the United Nations Economic Commission for Latin America, and the Caribbean (ECLAC, 2013) recognizes the importance of coordination for research across borders. Such practice could improve the dissemination of knowledge in those countries with shared interests in order to create a strong international network of scientists and evade the duplication of efforts. Thus, collective efforts to tackle regional challenges among science communities are meant to fix issues such as the distribution of public funds for scientific projects. Literature focused in Central America, also deals with other issues relevant to the formation and accumulation of the scientific workforce by means of engaging in international cooperation (Bonilla and Kwak, 2014; Bonilla and Kwak, 2015; Bonilla et al., 2018; Bonilla et al., 2019). Therefore, the Central American Integration System (SICA, 2020) may use SD practices by adopting partnership agreements with multiple stakeholders. However, despite the importance endorsed in building science communities in the region it has remained unclear if the participation of women in the research arena may result in major advances in interdisciplinary research.

MATERIALS AND METHODS

This study was carried out using a qualitative methodology in which three types of sources were used to collect data from women scientists in various fields in the participating Central American countries. Firstly, a "desk review" was undertaken to collect secondary data from reports, official documents, registries, and digital archives (Academia Guatemalteca de Ciencias Médicas, Físicas y Naturales, 2020; Ciencia en Panamá, 2020; SENACYT, 2020a; SENACYT, 2020b; SENACYT, 2020c).

Second, primary data was collected through semi-structured interviews with 43 women scientists. In order to ensure that principles of inclusion/exclusion were adhered to, those interviewed needed to fulfill each of three criteria: 1) women scientists with origin from one of the selected Central American countries (Origin), 2) accomplished researcher with recognition

TABLE 1 | Criteria – selection of key participants—semi-structured interviews.

Criteria	Description	Operationalization
Experience	Experience in community building or participation, networking, groups of scientists	Reporting experience in building and/or participating
Trajectory	Procure diversity in the representation of career development stages of the interviewees (early, mid-established career)	Years since completion of graduate studies. Early <10 years, mid +10 years but no management positions or group coordinators. Established +15 years in addition to management or research group coordination positions
Prominence	Influence beyond her immediate field of work, preferably with national/ international exposure	Publication, local or international award winning, participation in national and international activities in the scientific field
Field of Expertize	Diverse fields of knowledge (i.e., natural sciences, health, earth science, social sciences, physics, and engineering sciences)	All fields of knowledge were considered, including social, natural and engineering sciences

TABLE 2 | Key respondents: semi-structured interviews.

Cod	Country of origin	Stage in career development	Research area
GT1	Guatemala	Mid-career	Food Sciences (Nutrition)
GT2	Guatemala	Established-career	Social Sciences (Sociology)
GT3	Guatemala	Mid-career	Social Sciences (Interdisciplinary)
GT4	Guatemala	Mid-career	Health Sciences (Geriatrics)
GT5	Guatemala	Mid-career	Social Sciences (Statistics)
GT6	Guatemala	Early career	Earth Sciences (Limnology)
GT7	Guatemala	Established-career	Social Sciences (Psychology)
GT8	Guatemala	Established-career	Chemical Sciences
GT9	Guatemala	Mid-career	Social Sciences (Anthropology)
GT10	Guatemala	Mid-career	Social Sciences (STI Policy)
GT11	Guatemala	Early career	Natural Sciences (Toxicology)
GT12	Guatemala	Established-career	Life Sciences (Entomology)
GT13	Guatemala	Established-career	Food and Nutritional Sciences (Nutrition)
GT14	Guatemala	Early career	Engineering Sciences (Nanotechnology)
GT15	Guatemala	Established-career	Agriculture Sciences (Virology and Horticulture)
GT16	Guatemala	Established-career	Life Sciences (Biotechnology, Microbiology)
GT17	Guatemala	Established-career	Health Sciences (Pharmacology)
GT18	Guatemala	Established-career	Interdisciplinary (Women in higher education)
GT19	Guatemala	Established-career	Life Sciences (Entomology)
HN3	Honduras	Established-career	Natural Science (Biology), Engineering science (Environmental Engineering)
HN6	Honduras	Mid-career	Natural Sciences (Elemental particle physics)
HN8	Honduras	Established-career	Health Science (Microbiology, Clinical Chemistry)
HN9	Honduras	Established-career	Social Sciences (Economist), transpacific relations
HN10	Honduras	Established-career	Engineering Sciences (Agronomist, Economy)
HN12	Honduras	Established-career	Natural Sciences (biology, Genetics)
HN13	Honduras	Established-career	Engineering Sciences
HN14	Honduras	Established-career	Natural Sciences (Neurology, Neurosciences)
SV1	El Salvador	Established-career	Social Sciences (International Relations)
SV2	El Salvador	Established-career	Social Sciences (Sociology, Education)
SV3	El Salvador	Established-career	Social Sciences (Economy, Rural development)
SV4	El Salvador	Established-career	Natural Sciences (Chemistry)
SV5	El Salvador	Established-career	Social Sciences (Philosophy, Legal Sciences)
SV6	El Salvador	Established-areer	Health Sciences (Medicine, Cardiology)
SV7	El Salvador	Established-career	Natural Sciences (Chemistry, Physical, Geology)
SV8	El Salvador	Established-career	Social Sciences (Sociology)
PN1	Panamá	Established-career	Natural Sciences (Neurology, neurosciences)
PN2	Panamá	Established-career	Health Sciences (Public Health)
PN3	Panamá	Established-career	Natural Sciences (Biology, Molecular biology)
PN4	Panamá	Mid-career	Natural Sciences (Biology, Virology)
PN5	Panamá	Early career	Natural Sciences (Neurology, neurosciences)
PN6	Panamá	Early career	Social Sciences (Anthropology)
PN7	Panamá	Established-career	Social Sciences (History)
PN8	Panamá	Early career	Natural Sciences (Chemistry)

N = 43.

beyond her immediate research circles of influence (Prominence), and 3) experience in community building or community participation (Experience). A snowball and referral strategy was followed to build a robust list of potential participants. Diversity was sought in terms of representativeness by area of knowledge and stage in career development (early, mid-career and established) as described in **Table 1**.

Lastly, an online survey was designed and implemented for data collection. The online survey was sent to all registered members of the OWSD National Chapters of Guatemala (340), Honduras (57), El Salvador (60) and Panamá (2) at the time of the study. The total membership list was built based on public records as for December, 2020 on the OWSD international platform. The survey was opened for responses from November 3rd to 15th, 2020 and received a total of 175 responses.

From the application of semi-structured interviews nearly 60 h of audio material was collected. Each interview session had an average duration of 45 min. From a preliminary list of 55 potential key respondents with curriculum vitae that applied to the selection criteria, a total of 43 interviews (see **Table 2**) were effectively completed following a strict set of criteria (see **Table 1**), using various online platforms. For example, using Google-meets Zoom, WhatsApp calls, and Microsoft Teams.

The interviews were transcribed into text files and were codified and analyzed to determine patterns, trends, common content, and contrasting points of view. As for the Online survey, a total of 175 responses were received from Guatemala, El Salvador, Honduras, and Panamá with a resulting representation of 73,7, 10,3, 14,9, and 1,1%, respectively.

The compliance of ethics research guidelines was overseen by the Ethics Committee of the Technology University of el Salvador. All participants in the study provided informed consent to participate in the study and to publish the results, in accordance with national regulations and institutional requirements.

DISCUSSION AND FINDINGS

This section discusses data collected from the three qualitative methods as mentioned in *Discussion and Findings*. In order to provide structure and organization, five subsections are presented in this section. Where direct quotations were used, they have been categorized in order to facilitate the reading and respect the privacy of the participants.

Experiences in Building Communities of Women Scientists and Researchers

In general, community building among scientists is not widely spread in Central America. Instead, initial efforts are identified in the creation of networks and other groups of researchers, including both men and women. Most of the interviewees responded that they had taken part in some form of collective participation in their countries of origin, or in international networking platforms. Overall the respondents repeatedly emphasized that the networking experience was an emerging practice, still vastly unexplored.

In Guatemala, the scientists network most mentioned was the International Network of Science, Technology and Innovation (RedCTI)[1], which was founded in 2005. This organization has accumulated over 190 Guatemalan scientists residing within both the national and international territories. It is worth mentioning that the vast majority of members of this organization (71%) are men, with women members at 29%. The second most cited organization was the Guatemala Academy of Medical, Physical and Natural Sciences (AcaCienciasGt)[2] which was founded in 1945. This organization is restricted to certain fields of knowledge. As of June 2020, the Academy had a total of 76 members and only 23% are women. This figures are worth noting as science academies in Latin American countries generally have a higher representation of women with 17% compared to the global indicator with a representation of women stall at 12% (IAP the InterAcademy Partnership, 2016:25).

In El Salvador the most mentioned networking organization was the Network of Salvadoran Scientists REDISAL[3]. However, this is a scientific registry organization and not a network of scientists. It includes a directory of researchers from El Salvador and as of 2019 a total of 1,035 scientists were registered, 38% of whom are women. El Salvador has not yet established a national academy of science.

Interviewees from Honduras, mentioned two main communities of scientists in their country: The Honduras National Academy of Sciences, founded in 1983, with 34 members in 2016. From them 5 were women, equivalent to a 17% (IAP the InterAcademy Partnership, 2016), and *Honduras Global*[4], an international network of "accomplished Hondurans", including scientists and specialists from diverse disciplines. This network was formed in 2011 and currently reports having 54 affiliated members. This group does not have available data disaggregated by sex.

In Panama the most well-known organization for scientists is the Panamanian Association for the Advancement of Science (APANAC)[5] a private non-profit entity whose mission is to promote science and technology to build the basis of national development. It was founded on January 4, 1985, and has 88 members as of 2020. The second most-mentioned organization was Science in Panamá[6] a network of researchers formed in May 2016 which focuses on communicating science and seeking greater support from the civil society and decision makers within Panama, in order to increase the resources available for science and technology. This organization has about 150 members and provides a platform for scientific discussion, advice and promotion of the pressing challenges affecting the country.

[1]RedCTI https://redcti.senacyt.gob.gt/portal/index.php
[2]Acacienciasgt https://www.acacienciasgt.org/
[3]REDISAL https://www.redisal.org.sv/newAdmin/directorio.php
[4]Honduras Global http://hondurasglobal.org/
[5]APANAC http://www.apanac.org.pa/
[6]Ciencia en Panamá: https://www.cienciaenpanama.org/

The number of communities of women scientists in Central American countries is very low and there is extremely limited (nearly non-existent) support offered to such communities by institutions or local entities. Those few communities that are established for women scientists are short-lived (with few exceptions). The sustainability of their existence and activities appears to be dependent on individual efforts, including difficulties in transitioning leaderships, and communication difficulties between scientists from different generations and at different career levels. Once women in leading positions within women science communities retire several of the procedures and structures they have put in place may well close down altogether.

With regards to national communities exclusively formed by women in science, only a few were identified. In Guatemala, the most well-known community of women scientists is the Association of Guatemalan Women Scientists (ADEMCIT)[7] founded in 2000 and still active. In El Salvador the Association of University Women (AMUS[8]) which has been a reference of women's participation in higher education in the country since its foundation in 1952. Although this community has broader objectives beyond science and research it is also focused on education and training advancement for Salvadorian women. The second most-mentioned organization in El Salvador was the Network of Women Leaders in Higher Education (Red LIES[9]) which was launched in 2017, including ten universities committed to promote gender balance in academia, and is funded by the United States Agency for International Development. In Panama a number of organizations have promoted the participation of women in research communities such as the Feminist Women movement within *Ciencia en Panama* and APANAC, although they are not exclusively formed, nor focused on women. The Panama Smithsonian Tropical Research institute was also mentioned since it has promoted some initiatives specifically for women. Lastly, in Honduras there are no registries of communities of women scientists at the time of this study. It is worth noting that instead, the international Organization of Women in Science for the Developing World (OWSD) has registered members in all Central American countries. During 2020, this community established National Chapters in Guatemala[10] and Honduras[11], while El Salvador and Panama are still in the process of joining. Again, this is a global organization with national sections.

Barriers and Obstacles to Participate in Communities of Women Scientists in Central America

In both the interviews and surveys, respondents elaborated on the numerous barriers and obstacles to their participation in scientific communities. The data was organized for analysis and discussion based on the instrument for the semi-structured interview (available in the **Supplementary Materials**), the survey added content to the categories. **Table 3** below summarizes the main findings presented in this subsection. Excerpts of interviews are also included when relevant to enhance and elaborate specific issues.

Personal Barriers

The personal barriers are identified as issues at the individual level, negatively affecting the likelihood that Central American women scientists will take part in community building. In this context, the responses include: lack of time, multiple responsibilities, psychological perceptions, and gender roles. Respondents also cited multiple responsibilities which impinged on their freedom to participate in extra-curricular or career-development activities not offered by the institution where they work and study.

> The multiplicity of activities in which women have to fulfill responsibilities places enormous pressures which limit our available time. With very tight schedules few of us remain interested in creating or participating in associations. Also, many female scientists are still unaware of the benefits that networks and communities can offer to their personal and professional growth as women and as scientists. Rather, network participation seems like a way to socialize, very superficial, not really worthy of our scarce time (Participant HN12).
>
> I believe that we live in societies in which the multiple roles we are expected to play, put a burden on our shoulders which it is almost impossible to fulfill. Social responsibilities for women in the private sphere affect our careers (Participant GT3).
>
> I don't know of any groups or networks of women scientists in El Salvador. [I think] there is no interest. It has not occurred to anyone to promote this. What benefit will it bring? I would say both personal and institutional. If it is possible to combine these two things, it is fabulous. The economic part, because developing activities like these usually needs a budget and they want to give very little (Participant SV7).

Family Related Barriers

Family barriers must be taken into account both for those women scientists who have chosen to form a nuclear family with life partners and children, as well as for those who may have chosen a different path yet still have extended family-related responsibilities. It has been documented that the care of vulnerable and dependent family members such as elderly relatives and convalescent or disabled relatives generally falls on women (Hernández and Lara, 2015). Public policies are needed in each country to provide the conditions to enable a balance between work and family-related responsibilities for women scientists.

[7]ADEMCIT: https://ademcit.wordpress.com/2010/01/17/hola-mundo/
[8]AMUS: https://www.asociaciondemujeresuniversitarias.com/
[9]Red LIES https://www.laprensagrafica.com/elsalvador/USAID-lanza-Red-de-Mujeres-Lideres-en-Educacion-Superior-20171019-0127.html
[10]OWSD Guatemala https://owsd.net/network/guatemala
[11]OWSD Honduras Global https://www.owsd.net/network/honduras

TABLE 3 | Barriers to building and participating in scientific communities for women in Central America.

Individual/personal barriers	Related to (psychological, cultural, gender-conditioned) personal interest, aptitude, persistence, lack of resources, perception of lack of family and social support, psychological insecurity, poor health, and low self-esteem
Family-related barriers	Related to childcare, care responsibilities for convalescent/disabled relatives, families not conducive to female education and empowerment
Institutional barriers	Related to unsupportive or discriminatory rules and structures and their implementation, lack of access to educational programs and educational and science curriculums of quality, lack of support to the family structure, lack of incentives, lack of institutional wellbeing dynamics in general—culture of isolation and non-cooperation, lack of education and training of soft skills, e.g., leadership for women
Economic barriers	Inadequate, outdated and unsupportive legal framework, lack of economic resources for science at all levels
Social barriers	Scarce relevance given to science at all levels, direct, and indirect violence against women, underrepresentation of women in decision making processes at all levels

> Family responsibilities frequently represent disadvantages for women to take part in groups or networking. In El Salvador, women start their families during university education, this brings complications as they are expected to be educated and trained to become competent researchers, and at the same time take care of their families (Participant SV6).
>
> The absence of public policies that allow women to make their family life compatible with their work life. The traditional role expected of women in our society is burdensome in this sense. The multiple activities in which women are involved, do not give them any spare time in their busy schedules to be a part of building communities of women in science (Participant GT5).

Institutional Barriers

Institutions have an important role to play in promoting and supporting the participation of women in scientific activities through the implementation of gender-parity legal structures, high quality education (including soft skills) and women empowerment which is elemental for the construction of scientific communities. The institutional context includes any practice that may facilitate or hinder the construction of scientific communities, such as the structure, management style, and type of leadership. In general, from the answers received, it seems that, in Central America since there is little understanding at high level of the benefits to women of being members of a scientific community, with the result that institutions provide no resources or opportunities for such communities to be established. It is necessary to promote scientific research of high quality and encourage appropriate collaborations among individuals, groups, and leadership persons in order to initiate and enable participation within institutes. Making people aware of the importance and potential of networks must be an institutional responsibility.

In universities, the gender inequality dynamic between men and women is clearly evident and this limits the potential opportunities for professional and personal growth for women in science. This is demonstrated in the disproportionate representation of women in positions of authority within different institutions. This is particularly contradictory as Latin America shows higher representation of women in research compared to other regions (Lemarchand, 2010, pp 56–61), yet women are disadvantaged in terms of holding positions.

> The gender gap in higher education is striking. When we analyze the number of department directors and academic units the imbalance is appalling! The number of men in leading positions is disproportionally large, the number of women is dismal (Participant SV6).
>
> I think of the university; patriarchy has shown a strong resistance to gender issues. The situation has reached levels of misogyny, and a deep invisibility of women's work (Participant SV2).
>
> I think we have been evolving slowly and with differences between countries, some have acquired more rights and more support but there is still no comprehensive system (Participant HN9).

According to various interviewees, the structure of the institutions does not favor the development of science careers for women. There are no clear parameters for conducting research within organizations. This phenomenon is perceived in universities and research centers where researchers combine their teaching and administrative responsibilities. Many women are science practitioners within higher education institutions in Central America; however, their work goes largely unrecognized:

> Institutional recognition of women's participation in scientific communities is required. This issue has been addressed in the diagnostic report of women in science in Panama in 2018, Men [who usually make decisions in academia] have a bias about the role and value of women in science, they do not see us as peers, and this leads to the "scissor effect." At the moment women begin their careers as scientists, they also start their families, but institutions do not accommodate this, for men this is not an obstacle, yet women must compete at the same level as their peers. Institutions must create conditions that correct this bias and support the construction of scientific communities (Participant PN3).

In order for women scientists to have well-balanced family and professional lives an institutional effort is important and needed.

Therefore, institutions need to value the contribution of women scientists and fairly evaluate and empower women's engagement in science:

> Academic and research institutions here [in Guatemala] work like islands, isolated from each other, there are not many opportunities for interaction among female scientists and neither are there forums where we can exchange ideas and engage in initiatives of collective construction. I hope that the explosive growth in virtual communication and platforms will open many doors. For now, it is really hard to meet other women who share research interests. We work in very isolated conditions, even within the same institution. Where I work we are small islands within the same institution (Participant GT15).

Although the figures show great gaps between men and women in terms of academic titles, distribution of positions of power, and access to scientific careers, this reality is overlooked within institutions. Indeed, the narratives of respondents recommend raising and building awareness in women and encouraging them to gain ground:

> I find it very disturbing how institutions accept and normalize these tremendous differences in the representation of men and women among authorities, professors and researchers. What is more, the few women who manage to stay in academia do not receive sufficient stimulus and support from institutions. We continue in science because we love what we do, imagine how much more we could achieve in better conditions (Participant SV6).

These efforts can be oriented toward the construction of scientific communities of women in which scientific production is shown with equity and on equal terms.

> I know of attempts [at community building], and I have participated in attempts. These efforts to consolidate science collectively, if they do not have a central foothold that makes scientists form nuclei, will not be achieved, just getting together is not enough. If [such communities] are not initiated by government, they are very difficult to sustain (Participant SV4).

Economic Barriers

Interviewees stressed how essential funding is to starting a successful career in science. However, job instability for women undertaking scientific research living in Central America represents a serious obstacle to participation in collective activities. The women interviewed often describe working under unstable conditions, juggling between one or two jobs in order to make ends meet. Women scholars who have secured a full-time job in academia already struggle to fulfill their administrative and teaching duties, since research activities are not recognized as part of their full-time job descriptions (this frequently happen also for men).

> In my university we limit ourselves more to administrative work in our desks, I do engage in field research work but many times we have to use our own funds to do things, so that is very limiting. Speaking specifically as a woman, then perhaps one difficulty has been that the environment is dominated by men, so the way of working is sometimes very dominated by them, and the environment is very competitive too ... it's both good and bad. Sometimes it makes it difficult to accept a woman in a working group and well, sometimes we have to deal with difficult people, not all, but some ... but there are always so many men and women, not only men. So that has been the most difficult as a woman (Participant HN13).

Women interviewees expressed that despite having obtained scientific qualifications and skills they have found it difficult to develop their careers. Scientific development does not have concrete support in the countries under study.

> The limitation of the country [Panama] is that we are few, and there is a lack of infrastructure and funds to be able to integrate, especially in terms of women scientists. It is a limitation as there is a lack of a system that allows adequate insertion. Although we are a small country, there is not enough interaction between scientists in the city and those who live in the provinces, the way the city is conceived does not facilitate activities after work since time is wasted on returning home and takes away the opportunity for connectivity (Participant PN4).
>
> There are many issues to work on in Guatemala, the main limitation is job stability. That always worried me and I am reaching the age that I should think about retirement, but it has not always been possible to obtain funds for my work. Local funds are very scarce, and the type of grants that can be obtained through the national system are insufficient to support a meaningful and world-standard research project (Participant GT12).

Despite scientific job instability in Central American institutions the narratives of women interviewed suggested faith in the possibility of strengthening their scientific work with the support of private companies and the government. However, a positive vision from these actors (private firms and public institutions) is needed to promote and support women scientists' research productivity.

> Our employers and bosses are willing for us to form these networks but they see them as something secondary that has no real practical value, so the question is how do we

> motivate these institutions to give value to associations of this type? (Participant GT13)

Basco and Lavena (2019) confirm what was stressed by interviewees, that women's participation in the labor market in science and technology moves from exclusion to horizontal and vertical segregation taking into account the different economic empowerment scenarios.

Social Barriers

The social conception of networks of and for women in science is that they are unnecessary or tainted with "extremism" on the part of those scientists who wish to build them in the Central American region. The gender bias in education is not yet understood and when communities are exclusively formed by women (not only women scientists) they tend to automatically labeled as "radical feminist" organizations, confirming deeply rooted misogynistic prejudices in male-oriented societies. It is important to re-evaluate the role of women in science and technology and to rewrite history to recover women's or "feminine" traditions from oblivion. Despite having made notable contributions to the scientific-technological field, women are still not recognized for their contributions:

> Science in general is not a priority in my country, [therefore] the role of women in science is an element even further down in the social priorities. There is a divorce between academia and gender in El Salvador. Feminist studies, women studies in any field, the gender scope is absent. Women in science is still a pending issue. Let's say that it is a structural situation [barriers for women in science], that we can also take as an obstacle, in the sense that the development of science is very limited, including the social and natural sciences. The war greatly fractured the development of the sciences in El Salvador, in such a way that the university, I believe, still has not recovered from that, because communities, in general, have not been created, and much less so communities of women scientists, in any space, school or faculty. Because the conditions for this to happen did not exist. Who was going to coordinate the establishment of such communities from within the existing structures? As the gender perspective in academia has not and still is not considered relevant the few available studies have been carried out with the support of NGOs and therefore the scholarly community does not accept or validate them (Participant SV2).

The findings showed an established social role of household administration as one of the main barriers that women have to develop in the scientific world.

> The lack of participation of Salvadoran women in groups, networks or communities of researchers has to do with the issue of gender roles and stereotypes. It is very common for men to meet after work hours until midnight, or even in their own homes, to dedicate themselves to socializing and taking part in groups. Meanwhile, women have to run around to reconcile professional work with domestic work, I think that limits us (Participant SV3).

Despite the social barriers, the survey participants viewed the creation of science-related with optimism, and recognized that these networks can yield opportunities to overcome social barriers. However, the efforts needed to build networks or include scientists must take into account the multiple challenges that affect women:

> I think it is something very recent that these movements are beginning to take place, when I started my career they did not exist, they are still very few but I see that there is a movement that is interested in creating these research networks. I think we have to reach a critical mass of people who are working in research in the country to create these networks. Then having a volume of people who are working in the area it can make sense to form a collaborative network but if there are few people who are doing the work in the country it does not make much sense, that is why it is important that there are enough people working on the themes so that there are areas of common interest for the formation of these networks (Participant GT13).
>
> It is necessary to educate about a gender perspective; even in Panama it is considered "radical" to be part of a group of women scientists. On the other hand, I have no evidence in this regard, but I assume that those of us who are currently part of this group do so because our positions are not at risk (for different reasons). It is up to us to strengthen scientific and academic institutions so that more women at all levels of professional careers can belong to communities of women scientists without this implying professional risk (Participant PN1).

Various societies in Central America have experienced significant violence in their recent history. In Guatemala and El Salvador, both countries were involved in long-lasting armed conflicts in the second half of the twentieth century: for 36 years (1996–1999) in Guatemala and 12 years in El Salvador (1979–1992). These traumatic episodes have affected the entire Central American region, destroying multiple layers of social tissue, and discouraging the formation of and participation in collective processes (Navas, 2018). Knowing this context is important as various respondents point out the constant discouragement to collaborate and form groups affects most generations of Central Americans. As a result, women face specific challenges regarding creating and developing scientific communities.

Despite the efforts of many women to demonstrate the value of scientific activities, they are still undervalued by Central American institutions. This situation was also referred to by

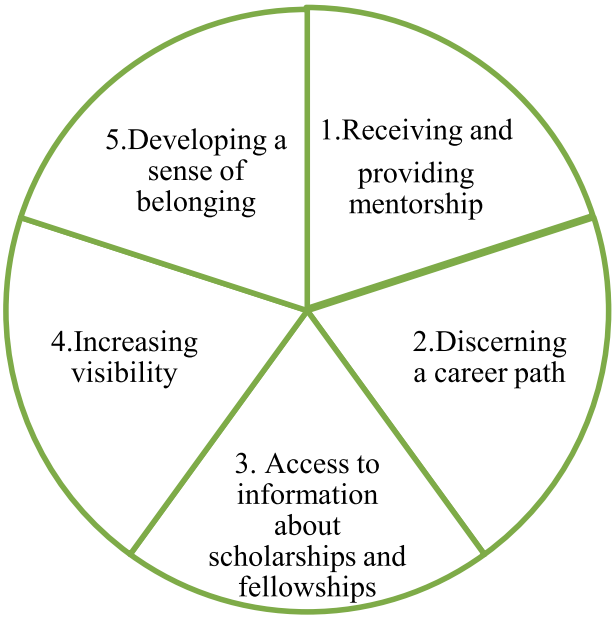

FIGURE 1 | Benefits and motivations to participating in a community of women scientists.

interviewees, who indicated there is a tendency for institutions and governments not to value or strengthen scientific research in general, much less that carried out by women. However, women have made efforts to overcome these barriers, as we can see from the following narratives, which suggest that there is a need for systematic work to provide women with the necessary tools to dedicate themselves to science.

> Women experience epistemic violence due to the androcentric nature of science and knowledge production. The system still doesn't take women contributions to science seriously. If we review even at the level of decision-making spaces within the university itself or within the different spaces of life in Salvadoran society, it is in the hands of men; The structures in academia concede privileges and attribute to men qualities which women do not enjoy; but it is not easy at all, in fact in the economics school to which I belong there are 35 faculty members, and only four of them are women. And this is striking considering the perception that in the Social Sciences participation of women is perceived as higher and more active compared to engineering, natural sciences and STEM fields (Participant SV3).
>
> In Panama, society does not see the need for women to build exclusive groups for them. We have low visibility, women are not seen as the experts they are, men have monopolized the public's respect and attention. In general, women are not recognized as experts (Participant PN7).

Benefits and Motivations to Participating in a Community of Women Scientists

Evidence suggests that a significant portion of Central American women scientists still overlook the numerous possibilities that group participation has to offer their career development. Nonetheless, when asked about the benefits (real or expected) of being part of a group or community of women scientists the participants provided the motivations shown in **Figure 1**:

Receiving and Providing Mentorship

In Central America mentoring has not been widely explored as a systematic practice among women scientists. However, several of the interviewees and respondents pointed out that providing and/or receiving mentoring is a key feature they seek when participating in networks or communities. (Oshinkale, 2019) provides a helpful definition of mentorship and the mentor-mentee relation:

> "A mentorship is a relationship between two people where the individual with more experience, knowledge, and connections is able to pass along what they have learned to a more junior individual within a certain field. The more senior individual is the mentor, and the more junior individual is the mentee. The mentor benefits because they are able to lead the future generation in an area they care about and ensure that best practices are passed along; meanwhile, the mentee benefits because they have proven that they are ready to take the next step in their career and can receive the extra help needed to make that advancement" (Oshinkale, 2019: first paragraph).

Mentoring (formal or informal) is seen as a mechanism to strengthen women's performance in various disciplines. In addition, interactions between women scientists in different stages of their careers enable broader understanding within science and lead to scientific collaborations. Mentoring also nurtures leadership and empowerment skills among women scientists. Most of the women with a consolidated career who participated in the study have been leaders in scientific initiatives in their countries. Some senior women also joined communities of women in science or became members of recognized scientific institutions. However, due to the time constraints, administrative work load and other duties, only a few have developed their careers as heads of their institutions or programs. Inequity persists throughout the different fields of the academy not just for research project selection, but also when it comes to publishing or applying for leading positions:

> During my undergraduate and postgraduate, I tried to be surrounded by other women and actively participated in mentoring. This allowed me to become even more aware of the gender perspective in Public Health research (Participant PN2).
>
> I benefitted from mentoring, rather informally probably because there were very few women at the beginning of

> my academic career. I see that after several years, the presence of women has increased in my field. I try to return the positive experience by being a mentor myself, it is also important to inspire the students and guide them. It is really helpful for girls to have female mentors (Participant PN7).
>
> I think men have been successful in building ties between them, establishing a sort of mentorship in informal settings, compared to women. They push each other up, or when they are up, pull up the aspiring young male researchers. We should work to create our own communities (Participant GT1).

Discerning Career Development

Women in science, and scientists in general, face challenges when it comes to combining their scientific career with administrative or teaching positions. Research activities are still not included as core duties in the description of job positions in both public and private sectors. The lack of scientific research within these sectors is a culture that needs to change, the experiences expressed by the interviewees emphasize this challenge:

> People in El Salvador get their [undergraduate] degree and then they stop there, if they find employment in a university, the truth is, there they stay, but there is no growth, there are not sustained interest in career development, there are no competitions, there are no incentives. In other countries, professors are encouraged to improve their knowledge, by being giving particular incentives (and salary raises) if they continue studying, if they participate in conferences, if they offer presentations, all of this is worth points in other universities. There is no involvement because if you are required to attend a conference you don't have funds because the university does not pay (Participant SV2).
>
> By joining our voices, we can be heard, we can grow stronger and faster in concerted paths. There are issues of egos as well, of mistrust, there may be so many reasons, sometimes we do not want to participate due to experiences in the past, that is why I think a few of collaboration between scientists can be beneficial (Participant HN14).

Access to Key Information About Scholarships, Training and Other Incentives

Central America has relied on international cooperation to educate and train its scientific force for decades. The underdevelopment of higher education systems and insufficient conditions to pursue graduate studies in the national territory (Bonilla and Kwak, 2014; Bonilla, and Kwak, 2015; Bonilla et al., 2018) has created a permanent search for scholarships, fellowships and financial funding to support studying abroad. Respondents expressed that among their main motivations for joining a network or a group is to have access to information about the availability of these opportunities to continue their education and training:

> Progressively the institutions are taking on perspective of the gender-harsh context in Central America. At first the role of women scientists was not evident, but we have advanced at least symbolically with recognition through local awards such as the L'oreal- UNESCO Women in Science fellowships, which already has had four national editions (Participant PN2).
>
> I obtained a scholarship to complete my graduate studies supported by a foreign government, otherwise I would not have been able to do so. After that experience, I realized there was an opportunity for me to encourage other Salvadoran women to apply for scholarships. That is why I joined various networks I could identify to pursue this purpose (Participant SV6).

Increasing Visibility, Exposure and Recognition

When women join communities they increase their exposure and the visibility of their contributions and career development. This exposure and recognition enables further impact in their societies as they act as role models for children and young girls. There is a staggering shortage of female figures engaged in science in the Central American. Nevertheless, various scientists interviewed pointed out that in their countries there is limited value and insufficient recognition for scientific activities and production.

> The evolution of communication, and social networks, has played a part in motivating girls and young women, letting them know that there are other women scientists opening doors for them. The implementation of institutional measures for gender equality, which is being worked on by SENACYT [The National Secretariat of Science and Technology] has a committee, with regulations, and more can be done. Also the encouragement of networks to put women on the radar of public opinion (Participant PN4).

Sense of Belonging

Women scientists have just started to organize in a more systematic and widespread practice in Central America. As the number of women participating in research and science activities increases the opportunities to connect are yet to be further explored. The role of women pioneers in science in this region is valuable and fundamental in order to bridge gaps and disrupt working in isolation. They can overcome steep barriers and start communities from scratch and they can inspire an upcoming generation of scientists. Thus, the interaction between women in different stages of their careers may connect, share ideas, work together and have a sense of belonging with recognition.

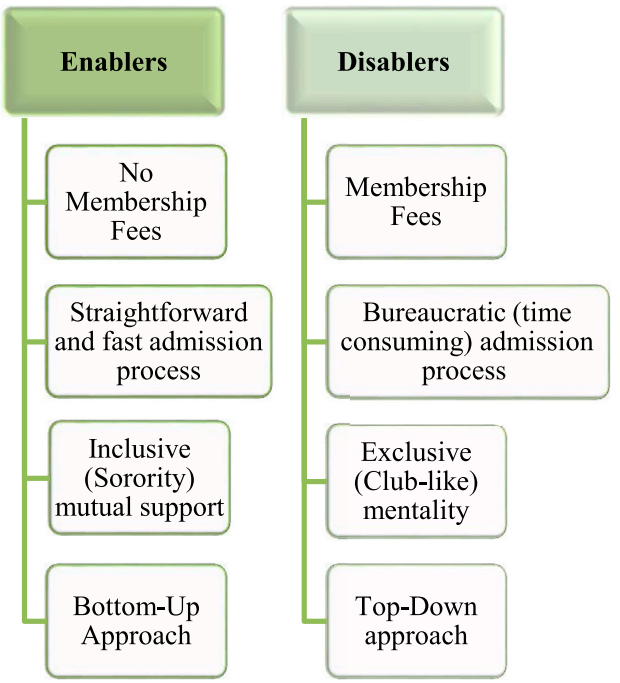

FIGURE 2 | Enablers and disablers in community building among women scientists.

Critical Perspective Toward Women Networks and Communities

It is important to acknowledge women in science that criticize this initiative and do not see the benefits of being part of a community of women. Some of them have indicated that when they became involved in research there were only a few scientists in the region and communication systems depended on meeting in person which entailed logistic hurdles, and the use of resources and effort. With the access to internet and mobile communication, relations between scientists from all over the world have been facilitated and interactions and building connections have become more accessible. Some women in science are still debating the benefits to invest time in communities as they indicate below. In some cases, networking and community building is perceived as a burden instead of a support mechanism for career development:

> I feel conflicted when thinking about groups of only women and wondering if that is effective. I think that for Guatemala it is necessary to grow together in networks, men and women, supporting each other, I think that for the good of the development of science all of us should be represented (Participant GT11).
>
> I have not actively engaged with communities of women scientists because I don't see it as a priority, and the benefits are unclear. Funds are not given for this activity. This must be adjusted. Also, if we think about mentoring within networks we have to be precise about who will benefit from it, which population will be targeted, and it must be well planned to be sustainable (Participant PN8).

Enablers and Disablers in Community Building Among Women Scientists

Considering the numerous barriers women scientists encounter either to construct or to participate in communities, it was important to explore the enablers and disablers of such participation. These are conditions, requirements or processes that could facilitate or further discourage women's participation in groups. **Figure 2** depicts the most often cited elements seen as facilitating or discouraging community participation.

Paid/Non-Paid Membership

Given the burden women in science experience in Central America in terms of job instability and lack of career development, the requirement to pay for membership was mentioned by various participants as discouraging them to take part in groups:

> An indisposing requirement to belong to networks or groups is a paid membership. Honestly even when it is not much money, we cannot afford it. Specially in precarious employment contexts for women in science I guess, there have not been enough initiatives to build communities and not enough commitment, but I also think that many women who want to participate just cannot pay membership fees (Participant HN3).

Simple/Bureaucratic Entrance Process

Some existing scientific networks in Central America were characterized by various respondents as having a bureaucratic application process in which they had to submit several letters of recommendation, proofs of academic achievements in printed documents and that the opportunity to join was open once a year; subjecting the approval to join to a general assembly. In other cases, participants indicated that the application process was time-consuming and difficult to follow guidelines led to confusion during the application process.

> To be honest, I felt a bit frustrated when trying to be active in a couple of groups of scientists in Guatemala. It took a long time to complete the paperwork to be accepted, and once I was part of the communities, they were too slow. Making decisions took a long time, in the sense of some directive members had almost veto powers (Participant GT1).
>
> I applied for membership in 2018 through a "speedy process" because my profile was recognized with an award which gave me a green light to join the group of scientists. It was two years later that my membership was approved, I think it was too long (Participant GT11).

Inclusive/Exclusive Practices

Higher education in Central American societies is affected by inequality (Cox, 2010; Bonilla and Kwak, 2014). In fact, inequality is both deep and spread out over multiple dimensions from race and gender to unequal access to education, health and other services (Busso and Messina, 2020). In this context access to university studies has been restricted to traditionally privileged groups in urban areas. There are several layers of exclusion that also affect leadership in research groups and networks. These conditions need to be taken into account, as the trends behind community building between women scientists have been depicted as taking either one of two approaches: inclusive diverse organization and exclusive prestige-based groups.

> Networks and communities of scientists too frequently are managed like clubs. You must take the initiative to reach a level with recognition to introduce yourself to those clubs. The way to do it is to have the endorsement that says "I would like to bring that person." Volunteering and doing hard work may not be enough. You need connections to be accepted (Participant HN8).

> In Guatemala there was an association of women in science, I think it was created in the 70s, unfortunately there was a very marked difference of social class, so I did not feel welcome. In addition, the areas of knowledge of the members were too confined around chemistry and pharmacy. Also, the leadership was very concentrated, rather than a horizontal, inclusive environment, decisions were taken by one or two members. Later, in the 90s, a group tried to give that association a spin, but they were unsuccessful (Participant GT2).

Bottom-Up/Top-Down Approach

Democracy for all citizens is still undeveloped in Central America. Most of the countries under study were affected by successive dictatorial military governments. This has affected social and political dynamics, the way citizens receive basic rights to education and the prevalence of centralized planning in public policies. This is relevant as the formation of national innovation systems in Central America has relied on the top-down approach (Padilla-Perez and Gaudin, 2014), and the formation of communities of scientists must be placed in this context. The answers provided by respondents suggest it would be beneficial to aim at organic organizational movement initiated from the grassroots (bottom-up), instead of promoting "compulsory" participation (top-down) based on official appointment.

> In various cases of networks and groups we were appointed by authorities to represent our institution. I believe this diminishes motivation, we have interpreted this as an extra burden to our workload instead of an incentive (Participant SV5).

> In my experience, scientific initiatives begin and are promoted by the government, the private sector does not get involved as it does not yield profit. We have left the responsibility to organize formal group organization of scientists to the government or public universities (Participant SV4).

Science Diplomacy and Women Scientists Community Building in Scientifically Lagging Countries

The inspiration for women in science to organize and identify the dynamics and benefits in building and participating in communities has come from abroad. As has been discussed earlier, the first Central American women engaged in scientific research worked in isolation in a predominantly male environment. A number of participants expressed the positive role that science diplomacy has played and mentioned that more could be done to encourage and support groups and collaborations between women scientists in Central America.

Cases of Emerging Science Diplomacy Experience and Community Building in Central America

Remarkably, various participants referred to assorted emerging examples of science diplomacy practices linked to networking and community building recently implemented in Central America. The promotion of scientific collaboration in national and international schemes could aim to solve regional challenges with a multi-actor perspective among countries with similar challenges.

> *Converciencia* is the annual meeting between Guatemalan scientists who work in research within and outside the country and broader sectors of the Guatemalan society. For twelve years SENACYT has promoted this activity with the vision of creating synergies between compatriots for the exchange of knowledge, experiences, good practices, and opportunity management and links that have an impact on the strengthening of a national scientific agenda. This event makes visible the quality and talent of the participating scientists and their commitment as Guatemalans, both residing in the country, and residing abroad, providing support from within their different disciplinary fields and contributing to the challenges and challenges of the country. In Guatemala we are in the process of integrating actions to address problems and challenges, and this activity allows us to foster spaces for interrelation that will help increase competitiveness (Participant GT11).

> *Honduras Global* was founded in 2011, and aims to identify and connect Honduran and highly qualified worldwide scientists in order to promote the transfer of knowledge and promote innovation and scientific, technological and business development in Honduras.

> It is worth noting that our priority activities revolve around innovation, science, technology, and entrepreneurship. The initiative has had some support in terms of funds from the Honduran government that varies according to the administration. Also, it has support from local research entities, there has always been a very good exchange with universities in Honduras, mainly with UNAH [National University of Honduras], which in my view is a very important entity at the national level for certain careers, and we have had collaboration with private companies and it has been very fluid, but regarding your question about collaborating with multilateral organizations, this has been quite difficult to establish (Participant HN10).
>
> In collaboration with the Gorgas Institute for Health Studies, in 2006 the Health Diplomacy program was developed together with the United States Department of Health, but it covered a collaboration with the entire Central American area, specifically focused on influenza. This experience was later transferred to the Center for Disease Control and expanded to HIV, in the latter they worked with countries such as Costa Rica and El Salvador. Other projects such as those developed with the University of South Florida were more aimed at high-risk and vulnerable communities such as indigenous regions (Participant PN2).
>
> [In my university] we are part of the Superior council of Central American universities, and through this platform we are trying to improve the quality of researchers of scientists in Central America and so this could be called science diplomacy. But it seems to me that this is being led more by the universities than the government (Participant HN13).

Opportunities for International Engagement and Science Diplomacy Practices Addressing Community Building in Central America

In recent times, efforts have been made by international organizations to achieve science diplomacy practices in the regions under study. The aim is to open a window of opportunities that create scientific communities with a balanced gender perspective. For example, the General Secretariat of the Central American Integration System (SICA, 2020), together with the Central American Higher University Council (CSUCA) and the Commission for Development Scientist and Technologist of Central America and Panama (CTCAP), with the support of the International Development Research Center (IDRC) of Canada collaborated to promote regional scientific collaboration. In 2020 they launched a Regional Call for Projects for the Organization of Central American Networks and Communities for Scientific Exchange where researchers in the region were encouraged to submit proposals, and highlight regional priorities in the context of the COVID-19 pandemic.

(1) Central America integration

Placing gender imbalances, differences, and gaps as priority topics on the agendas of policy makers is critical in Central America and vital to their potential incorporation in national Science and Innovation proposals and programs.

(2) Mapping out the Central American women scientific diaspora, through robust directories

There are no consolidated directories of women scientists which include the Central America scientific diaspora. Informal networking through social media (Twitter, Facebook, Instagram) as tools to connect has been of interest in recent times. This topic was addressed by some of the interviewees:

> [The OWSD national chapter in El Salvador] should map how many women do research and distinguish by area of knowledge. It would be valuable to increase the visibility of Salvadoran female researchers, so we can know them. The information must be more dynamic so that the benefits can be seen more and more participation. Academic women need spaces for development. I believe that this network has great power to fill real needs or disseminate the opportunities that exist. Communicate what we have and promote national events to meet the entire Salvadoran scientific community, including all those who reside abroad (Participant SV1).
>
> I think that maybe this is the moment to create a scientific community of women in Honduras. Before, there were very few of us, the efforts made did not bear fruit, but right now, for example, in the physics department there are many girls studying abroad, engaged with scholarships, holding conferences, performing well in international collaborations. There are Salvadoran women in the United States, working with NASA, also in astrophysics, and in other countries. I think this is the right moment to consolidate or settle the foundations for a community (Participant SV7).
>
> We need to highlight more women scientists in Honduras or those Hondurans in the scientific diaspora, make spotlights in the different scientific areas, and show who the women are behind these disciplines. Within the scope of the study of journalism, the person who interviews you must be a journalist who has training in science and technology. We need to involve the private sector, academia, public institutions and wider society (Participant HN8).

(3) Institutional Reform within the Ministries of Foreign Affairs

There is a gender gap in foreign policy in Central America. Generally, women are underrepresented in foreign policy circles and this is not new. The diplomatic circle also remains

overwhelmingly male-dominated. Even in international negotiation events and activities promoted in Foreign Ministries of the region most speakers are men who represent their governments. Thus, there is a risk of missing important insights that women can incorporate to science diplomacy and community building with a gender balance.

> When I observe the handling of my country's foreign policy, we generally see men as delegates, as representatives of the Salvadoran State. For example, I observed the case of the Japanese cooperation, that is, if they do a lot of scientific research with my university, it will be with the Faculty of Agronomic Sciences, where we know that they are mostly men. I do not know from first source how many women are participating in this or how many women have the opportunity to participate in these exchanges in a personal capacity or as institutional representatives. There is still a huge gender gap (Participant SV3).

(4) Science Diplomacy and Policy Advice

The COVID19 pandemic has put scientific advice to the forefront in guiding and providing solutions. Various actors (including scientists) started focusing on how science should be taken into account to inform and advise decision makers in situations like COVID-19. The challenges are related to how scientists communicate the results of research findings and transmit the importance of these results to our wellbeing.

> For me, having the opportunity to research, publish results, or found groups of researchers, has been a complete journey. My work is in the entire experience, not just doing research and publishing, which is the expectation. But taking the research to the next level has been very interesting, then being able to influence policies in programs by being part of the lobby, even before the national congress and before other entities has been a very good experience (Participant HN14).

(5) Science Diplomacy and studies about women's careers

Science diplomacy could also have an impact on the production of further studies, materials and information about gender gaps in science in Central America.

> Science diplomacy could contribute above all with studies of women scientists in Central America, then we could see the progress of gender in science around the world and have a better perspective. I heard of interesting initiatives in the Global Young Academy, particularly with respect to what happens in the scientific career before the age of 40 and what will be seen later in their career development (Respondent PN4).
>
> I believe that OWSD Guatemala National Chapter in its different work teams is working in a certain way on that since we are not replacing what a ministry or secretariat does at the government level, I believe that we are integrating ourselves as women to be able to work as a team on issues that we are passionate about and that is key, and it would be good to have international support for this (Respondent GT14).

Critical Perspective of Science Diplomacy

Many of the collaborations involving science diplomacy have been carried out without the explicit use of such terminology. Scientific and technological exchange is expanding and opening the opportunity for more collaborations in the region. Yet the lack of understanding of the concept of "science diplomacy" increases the risk of misunderstandings.

> I was in charge of that for 10 years at PAHO working with international health, I think that in international health it is basic and it is essential to use science diplomacy tools, but I have problems with the term "diplomacy" next to science, it is like a qualifier, a deviation of the core (Participant SV6).

Mistrust in the links between politics and academia is a dilemma that needs to be considered: sometimes there is misalignment or conflicts of interest:

> Science and politics are closely related. The downside is prioritizing one over the other. It has never seemed to me that the University of El Salvador prioritizes politics over science. Science can help El Salvador to make progress toward development. I think that these two fields can interact [science and policy], but you have to think about cooperation between sectors. Links need to be established with institutions and their support must be sought for any initiative, if there is no institutional support, no project can work (Participant SV7).

The predominance of the English language in international engagement might be a counterproductive component. For women in Science English language is mandatory if they want to continue their studies and research outside the Latin American region. Most scholarship applications and information are in English, available host institutes teach in English and vital publications are in English. Sometimes even a third language is needed. In Central America, where Spanish is the first language of most citizens, English is always at the very best a second language and is therefore a significant barrier for women who want to get access to higher level education.

> With proficiency in English, it is possible to participate in conferences, publications and communicate the knowledge that has been produced, publish it internationally; you have to have that knowledge first and consolidate the language well to be able to do it. (Participant HN10).

CONCLUSION AND IMPLICATIONS

Central America faces pressing unbalanced female representation in science. The significant gaps the region faces in terms of science and technology capacities are also reflected in the limited experiences within the region of building communities among women scientists. While exceptional networks among women scientists have been reported, the gender perspective has been given marginal attention. Valuable initiatives were identified aiming at organizing groups of women scientists. However, some of these initiatives were episodic interventions with no sustainability. In other cases, well-intended leaders mobilized an important number of researchers to form communities, yet different factors impeded the communities to survive and faded over time. In other words, the few cases of community building among scientists in Guatemala, El Salvador, Honduras and Panama, are meaningful and provide lessons to understand why the existence of such communities is so limited and highlights the different barriers faced particularly by women researchers. In scientifically-lagging countries, the construction of communities of women scientists has special relevance as the number of well-trained researchers is still low and the actors involved in research ecosystems are still developing. Community building among women scientists in Central America offers an array of opportunities and benefits that can have a positive impact on their individual career development. More importantly, increasing the presence of women in science inspires children and young girls and reduces the pervasive gender gaps in science which are evident in these countries.

The women pioneering in community building in the scientific field have had to overcome several barriers at the individual, family, institutional and societal level. Most of those barriers remain present in their everyday activities such as: gender stereotypes, imbalances in the pursuit of family/professional life equilibrium and socially-assigned roles. Findings suggest there have not been systematic institutional policies at the national level to foster community building among women scientists in Central America. The existing examples of community building, although valuable have remained temporal and eventually have been discontinued. These outcomes are the result of numerous difficulties involving the unmet needs of nurturing leadership, connecting women in different moments of their careers (generational breaks) and the lack of resources. In addition, the challenges discussed in this article leave women scientists with very limited resources, energy and motivation to engage in community building exercises.

In this context, science diplomacy practices have played a key role in supporting incipient community building among women scientists in Central America and represent a helpful conceptual framework to shift the prevalent top-down paradigm toward a bottom-up approach. Some of the areas in which science diplomacy may incorporate further possibilities to encourage and support the participation of Central American women in communities include: mapping the scientific female diaspora, facilitating collaborative work with women in other regions, enable achievement of milestones in the career development of women, nurturing leadership, and mentorship, among others. Guatemala, El Salvador, and Honduras have relatively similar contexts, while Panama shows more advances in community building among women scientists. Specific actions have been taken by the Panama National Secretariat of Science and Technology producing focused reports on the participation of women in science (SENACYT, 2020a) and partnering with stakeholders from other sectors to provide a career development path for women in science (SENACYT, 2020b). In addition, Panama was the first country in Latin America with a national strategy in science diplomacy (SENACYT, 2020c), with the decisive involvement of the Ministry of Foreign Affairs and SENACYT, among other stakeholders of the science and technology ecosystem.

In summary, science diplomacy could incorporate further actions regarding community building among Central American women through the observation of principles such as inclusiveness, networking, and deliberation:

(1) Science in Diplomacy: this perspective could strengthen the conventional international engagement of Central American countries with further elements of capacity building through training with evidence-based educational programs in topics such as: intercultural relations, networking, effective communication, leadership, negotiation, empowerment, conflict mediation, emotional and social intelligence, science communication, languages, strengthen scientific capacities to female scientists. By strengthening these communities and networks a directory of female scientific advisors and specialists could be created. There should be a focus on addressing special challenges and for the creation of evidence-based policies from a bottom-up approach. Diplomacy for Science: this can be a tool for articulating why networks are necessary to strengthen the role and activities of female communities. For example, multi-actor involvement (i.e., academia, government, private sector, national academies of sciences and civil society) can create sustainable models and the win-win negotiation of equal access and opportunities for all participants. Diplomacy also plays an important role in identifying and grouping together national communities that have been established in the diaspora. This could help the establishment of new channels of cooperation and networking. Special consideration could be given to scientists working abroad and how they can enhance mutual and beneficial collaboration with those scientists still based in the home country. In a similar vein, training in diplomacy can help science negotiators obtain better conditions. For example, access to opportunities for engagement with national scientists and institutions should be encouraged for both those researchers based in the home country and those currently residing in the diaspora. Links between these scientists and regional and international organisms could be facilitated, with, for

example, special relationships established between SICA, UNESCO and initiatives for women in science. In this way, other actions might be facilitated such as the multinational allocation and creation of projects for research, fostering scientific mobility, intra-regional focused activities, and the promotion of private investment for science. In all of these activities, it will be essential to have an underlying strategy of gender inclusion and awareness in those scientists who represent their nations at national and international levels.

(2) Science for Diplomacy: Central American community building can play an important role for diplomacy. For example, the uniqueness of the social and geographical conditions of the Central American region positions the territory as a natural laboratory for science. Through collaborations enhanced by communities with international peers and institutions not only can we enhance science locally and globally but also tighten relations with our traditional commercial and political partners while at the same time reducing the barriers with other countries in which there is a lack of adequate diplomatic relations. When scientists unite to study the common challenges in the region, this creates an ecosystem for gaining spaces in decision making and impacting societies at a national and international level through evidence-based culturally adapted mechanisms. Community Building in the post-pandemic world will provide a changing scenario with the use of different platforms for interactions. Numerous respondents referred to logistics, transportation, and other elements of physical mobility as obstacles for in-presence interactions among women scientists within their countries. With these recent experiences of on-line interactions, further exchanges and collaborations could be achieved.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The compliance of ethics research guidelines was overseen by the Ethics Committee of the Technology University of el Salvador. All participants in the study provided informed consent to participate in this study and to publish the results, in accordance with the national regulations and the institutional requirements.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication. The leadership and coordination of corresponding author KB in the research process and in the writing of the research report is acknowledged.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frma.2021.661508/full#supplementary-material

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Institutional Capacity for Science Diplomacy in Central America

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Science, technology, and innovation (STI) is increasingly gaining in importance on the foreign policy agenda of governments worldwide. However, the implementation of science diplomacy strategies requires STI institutional capacity and strong interfaces with policy and diplomacy. This research first maps the STI public institutions of the six member countries of the Central American Integration System (Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panama) and then draws their capacity to connect internationally in order to highlight their potential for science diplomacy. Variables such as the year of creation and mandates of scientific councils, secretariats, national academies, international cooperation departments and ministries are analyzed. The study reveals several public management challenges stemming from the institutional disparity and complexity of the region, already marked by significant asymmetries of human development between the various countries. Highlighting and understanding such challenges may be helpful for countries in the region in developing meaningful strategies around science diplomacy.

Keywords: science diplomacy, institutional capacities, international cooperation, central America, foreign policy

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INTRODUCTION

Climate change, infectious diseases, and food scarcity are amongst the many challenges that Central America is currently facing. Although science, technology and innovation (STI) issues are increasingly gaining in importance on the agenda of governments, different institutional and geopolitical integration challenges persist. Beyond the deployment of appropriate national STI policies in Central America (Lemarchand, 2010), responding to these complex issues will also require properly integrating science and foreign policy, leveraging scientific networks internationally and a coordinated response between countries in the region.

Science diplomacy is a relatively new field of scholarly study that focuses on these issues. While it has been pointed out that its exact aims, scope and stakeholders are still ill-defined (E.g. Kaltofen and Acuto 2018; Legrand and Stone 2018; Flink and Rüffin 2019; Ruffini 2020 and references therein) and that it is sometimes used as a convenient solutionist narrative (Rungius and Flink, 2020), science diplomacy has been taken up by advanced economies and scrutinized by scholars (E.g. Flink and Schreiterer, 2010; Ruffini 2017, Krasnyak, 2018; Ruffini 2021) and has gained ground in some of the BRICS countries (E.g., Pandor 2012; Oliveira Anunciato and Marques Sá dos Santos, 2020; Griset 2020). Despite the growing interest for science diplomacy in Central America (e.g., Panama), little academic attention has been devoted to the region and in particular its respective national institutions and their capacity to engage regionally and internationally (Gual Soler, 2014).

When focusing on science diplomacy as driven by the state, one of the taxonomies (Gluckman et al., 2017) proposes that it seeks to advance a country's national needs, address cross-border

interests and to meet global needs and challenges. States use a variety of institutions to engage along these broad lines, sometimes in a concerted manner that could be construed as a science diplomacy "strategy"[1] (E.g., Ruffini, 2021). Since priorities may vary from state to state, no single science diplomacy strategy can be identified: these depend on their cultural and political context (Flink and Schreiterer, 2010; Krasnyak, 2018; Epping, 2020). In many cases, states have yet to actively engage in science diplomacy (whether through a strategy formulated in advance or in an ad-hoc manner) or to recognize the potential of its institutions to do so. In some instances, they may simply not have the institutional capacity.

While the stakeholders responsible for the strategy vary from country to country (E.g., the Ministry of Foreign Affairs or MoFA, an inter-ministerial task forces of its MoFA and Ministry of Science and Technology or sometimes a mix of institutions, etc.,), it nonetheless relies on the capacity of the state to mobilize its ecosystem through its own national institutions. In order to start formulating a strategy for science diplomacy, it is therefore necessary for states to take stock of their institutions, their inter-linkages and interfaces between science and diplomacy. While research is still lacking on what can be considered institutional capacity for science diplomacy, it is clear that having national institutions that are already engaging internationally in science is a helpful starting point. In this paper, we therefore carry a first landscape analysis of the STI publicly-funded institutions in Central America and their potential to engage in science diplomacy, identifying challenges and opportunities specific to the region.

RESEARCH OBJECTIVES AND METHODS

The purpose of this research is to analyze the institutional capacity for science diplomacy of the six original (1991) member countries of the Central American Integration System (SICA): Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panama. We first mapped these countries' STI public institutions, and then looked at their capacity to connect internationally as a means to highlight their *potential* for science diplomacy.

According to Elorza et al. (2020), the most common objectives of science diplomacy strategies are: "1) strengthening bilateral scientific collaborations and the support of countries' STI interests, 2) facilitating evidence-informed positions of the country in multilateral endeavours and global challenges, 3) bringing new scientific opportunities and scientific talent to the country, 4) using scientific collaborations as a tool for improving bilateral relations with strategic countries, 5) acknowledging STI as a key asset of the country in its image abroad, 6) facilitating country companies to have a good place in the international innovation market as well as in the research and development international arena". This research is restricted only to a subset of these objectives and focuses on objective one (and by proxy, objectives four and five) by looking at ministries and on objective two by looking at scientific councils and national academies. It is however important to note that objective one needs to be "coordinated" institutionally to be construed as part of science diplomacy (Krasnyak and Ruffini, 2020). This paper considers the *potential* for these institutions to align with the nations' foreign policy, not whether they are engaging in science diplomacy already.

The state can leverage a host of stakeholders for science diplomacy, from its own ministries to universities, the private sector, its scientific community at home or diaspora overseas, etc., maximizing and aligning their actions with the state's perceived needs in engaging in science at the international level. However we choose here to restrict the scope of our analysis to public institutions. The unit of analysis of this research is therefore "STI national institutions", meaning (publicly-funded) national and centralized agencies that provide scientific and technological services in Central America. Institutions analyzed here are therefore ministries, scientific councils and most national academies.

It is also worthy to note that while science encompasses natural sciences, engineering and social sciences, here we choose to restrict our analysis to the first two. In addition, STI here covers the realm of basic sciences to the applied sciences and innovation derived from natural sciences and engineering (while noting that the innovation process should not be construed as linear one and that social sciences also contribute). Nonetheless, this means that we choose to restrict our subsequent analysis to the following sectors: science (as a general denomination), health, agriculture, energy, environment and education (the latter is partly focused on STI), leaving aside social issues such as housing, infrastructure, transport, economy, commerce, development and industry. It is however necessary to mention that part of the STI spectrum is therefore missing from this initial analysis.

The research process was developed in five phases. First, each of the government ministries which provide a scientific or technological service was identified for every SICA country. This includes looking at ministries working on health, agriculture, energy, environment and education, and those labelled as more broadly focusing on "science and technology". Second, the organization chart of each of these government agencies was reviewed (using their official websites, available documentation, academic and grey literature) to identify international cooperation departments within them. Then, we identified all the scientific councils and national academies of the region through grey literature and websites of various organizations such as the "Inter-American Network of Academies of Science" (IANAS)[2] or the "InterAcademy Partnership" (IAP)[3].

[1]Rapport, "Une diplomatie scientifique pour la France", Ministere des Affaires Etrangeres, 2013, https://www.diplomatie.gouv.fr/IMG/pdf/Rapport_Complet_DiplomatieScientifique_2013_cle8a68fb.pdf

[2]https://ianas.org/

[3]https://www.interacademies.org/

The fourth stage was to analyze the mandate of these STI national institutions, with an emphasis in their roles and responsibilities towards internationalization. Finally, a database was built to organize key information on all these institutions which includes the following eight variables: 1) the name of the entity, 2) the SICA country to which it belongs, 3) the type of institution (a ministry, a scientific council or a national academy), 4) its acronym, 5) year of creation, 6) thematic focus, 7) a list of its international cooperation units when available, 8) the broad mandate of the entity. The database lists 45 entities, including 33 ministries, eight scientific councils, and four national academies.

This is the first inventory that analyses the range of actions of these institutions as potential science diplomacy actors in the region. However, the study has several limitations. First, this mapping does not include local governments, decentralized government entities or other stakeholders in Central America which could be important for their scientific and technological international engagement (E.g., higher education institutions, private sector or organized civil society). More importantly, this simple inventory of institutions and mandates does not address whether they are working well, if coordination is effective nor how their activities are perceived internationally.

RESULTS

The first step was a mapping of the main STI publicly-funded institutions in the SICA region (here encompasses ministries, scientific councils and national academies) and the second to analyze their mandates and structures to engage with the international realm.

It is useful to first (re)-take stock of these institutions in their national context and do a short comparative analysis across the region. Indeed, highlighting similarities (or differences) across national STI ecosystems may provide some useful clues for the capacity for national science diplomacy strategies, cross-border collaboration along similar STI themes or the development of concerted regional foreign policies in STI. **Figure 1** summarizes the different actors identified in this research at the ministerial and departmental level (respectively in blue and orange), as well as the scientific councils (in green) and national academies (in purple) of the SICA region.

STI-Related Ministries

There are 27 government ministries (featured in blue in **Figure 1**) with an STI focus (as defined in *Research Objectives and Methods*) in the SICA countries. These national agencies address issues of science, health, agriculture, energy, environment, and education. The institutional design in each of these topics varies from country to country. The most striking feature of the region's government institutions is that Costa Rica is the only country with a dedicated Ministry of Science and Technology (MICITT, created in 1990). Another peculiarity is that El Salvador created a Vice-Ministry of Science and Technology within its Ministry of Education in 2009. According to an analysis of their mandates, both have similar functions (since they are the governing body in STI issues): they are responsible for coordinating the "national STI ecosystem", which includes the design of STI policies[4].

Looking at the year of creation and mandates of these 27 institutions, a noticeable common feature shared by the region is that these were created in two main waves of institutional experimentation over time. The first wave included the education, agriculture, and health portfolios, which were implemented from the second half of the 19th century until about 1950. By that time, the entire region already had ministries covering these topics. In most cases, the other ministries (environment, energy, and science) were then part of a second wave of institutional innovation that mostly occurred after 1990. For example, most SICA countries created ministries with an environmental focus after 1990 (with the exception of Honduras' "SERNA", created in 1954). Ministries dealing with the energy sector were also created during this second wave, such as Costa Rica (1990) and Nicaragua (2007), although Guatemala did so slightly before (1983). This second wave of creation of ministerial institutions is interestingly correlated with the birth of other STI-relevant institutions, the scientific councils, which we focus on in subsection b) below.

The second dimension of this analysis then focused on the international outlook of these ministries. If Central American governments are using science and technology as a tool to respond to global challenges, what institutional capacity do they have to engage in international scientific collaboration and (government-driven) science diplomacy? As a proxy, the research identified the international affairs departments within the STI ministries as a potential building block for a science diplomacy portfolio. In addition, international cooperation has been considered a key instrument in building capacities in science and technology in Central America (Bonilla, 2018).

As shown in **Figure 1**, there are 20 international affairs units (in orange) within the STI ministries (in blue) analyzed in the section above. The number of such units is uneven from country to country. All the ministries (as defined in *Research Objectives and Methods*) of Costa Rica, Guatemala and Panamá have an international cooperation unit, followed by Honduras (to the exception of SEP, **Figure 1**). In Nicaragua only two ministries (health and education) have such a unit and in El Salvador only one does (agriculture). The approach also differs widely from one country to another: the portfolios that these units may be tasked with are disparate across the region, which may present a challenge for regional coordination. Most seem to have been created in the 21st century, except for the case of the department at the Costa Rican ministry of education (1982) and the one within the ministry of agriculture in Panamá (1990). Finally, the names of these units vary considerably even within the same country: for example, in the case of the MSPAS in Guatemala, its "strategic planning unit" is in charge of the international cooperation of that ministry.

This landscape analysis of several STI-focused ministries and their institutional capacity to engage with the international realm through their international affairs units is only a first step, however. A crucial next step would be to investigate their links

[4]According to Law No. 7169 (*Law for the Promotion of Scientific and Technological Development* of Costa Rica) and from Decree No. 234 (*Law of Scientific and Technological Development* of El Salvador).

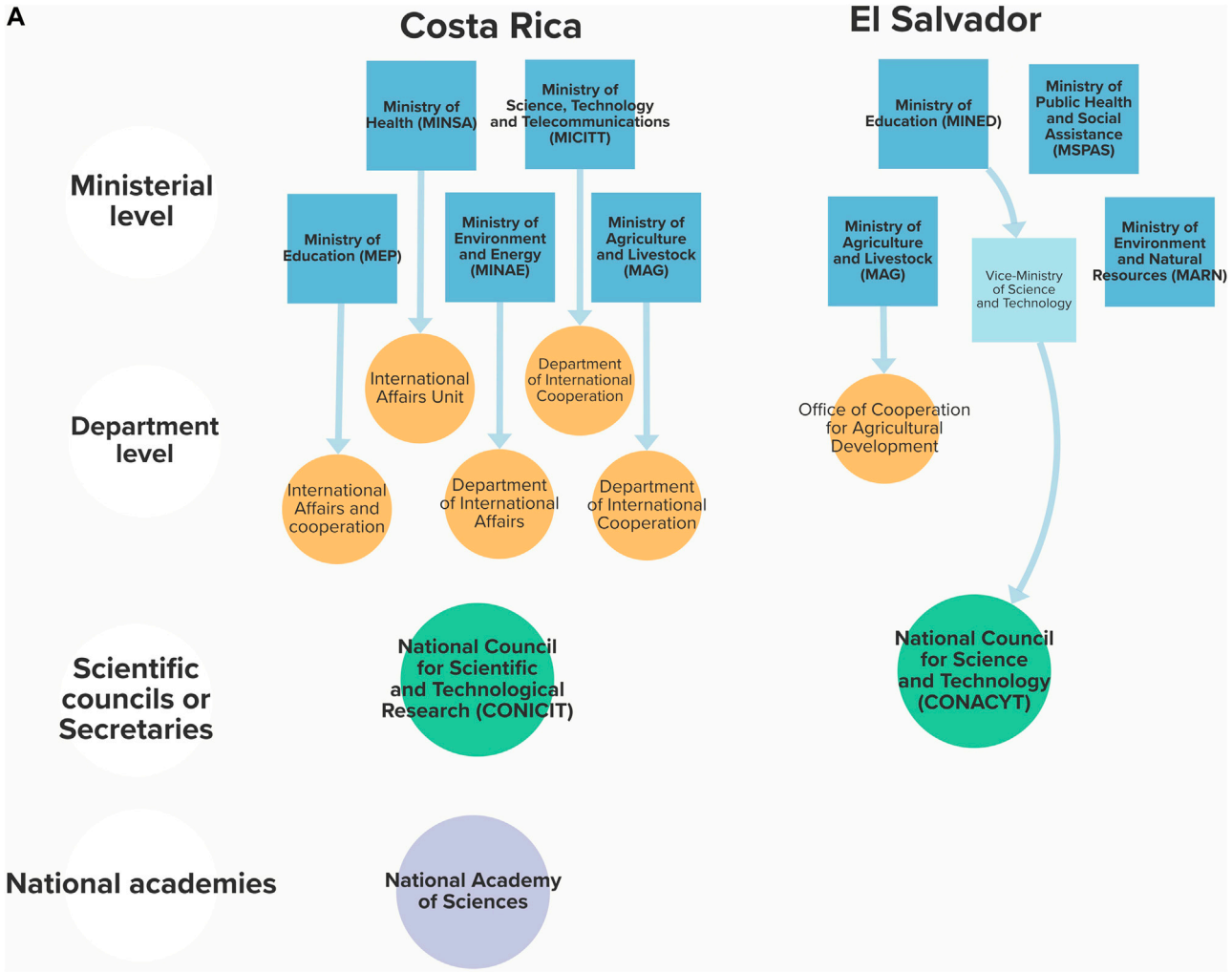

FIGURE 1 | A mapping of the institutional capacities for science diplomacy in the six SICA countries (2021), arranged by alphabetical order (from left to right and top to bottom). The figure shows the ministries and vice-ministries in blue (first row) and their international cooperation departments in orange (second row), the scientific councils or secretaries in green (third row) and the national academies in purple (fourth row). Note that some entities may be missing due to specific definitions of 'STI institutions' (see *Research objectives and methods*).

and overall policy alignment to their countries' MoFA—or other ministries that could be equally important in designing a strategy (in Costa Rica for example, the Ministry of National Planning and Economic Policy coordinates the country's international cooperation). This would require interviews, surveys or specific field work and is beyond the scope of this paper.

Scientific Councils

In this next subsection, we focus on the scientific councils in SICA, taking a closer look at their year of creation, mandates, institutional arrangements and linkages. These, alongside national academies (see *National academies*) can play a role in fulfilling parts of a science diplomacy strategy.

As can be seen in **Figure 1**, all SICA countries have scientific councils or secretaries for STI. Most were created in the 1990s, with the exception of Costa Rica and its National Council for Scientific and Technological Research (CONICIT), established nearly 2 decades earlier in 1972. The institutional arrangement of these scientific councils has evolved significantly over time, resulting in a complex picture which is not captured by **Figure 1**.

The case of the Honduran Council of Science and Technology (COHCIT) is a clear illustration of this complexity. The Council was created in 1993 and then replaced in 2013 by two entities: 1) the National Secretariat for Science, Technology, and Innovation (SENACIT) and 2) the Institute of Science, Technology, and Innovation (IHCIETI). Both are an integral part of the National System of Science, Technology, and Innovation of Honduras[5]. This transformation was originated by the law for the promotion of scientific and technological development passed in 2013 (No. 276-

[5]Together with the National Council for the Promotion of Science, Technology, and Innovation (CONFOCIT) and the National Fund for Financing Science, Technology, and Innovation (FONAFICIT).

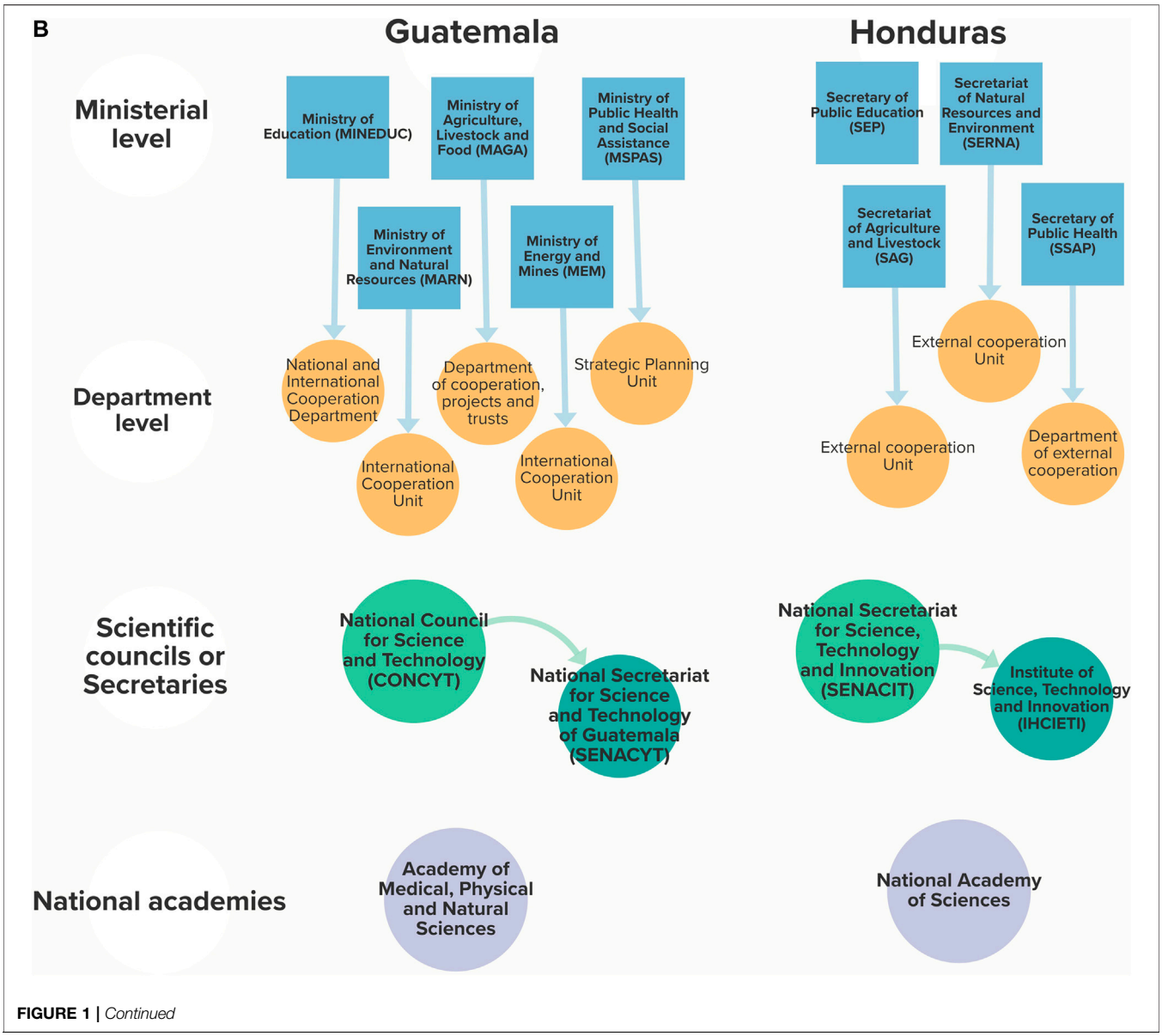

FIGURE 1 | *Continued*

2013). It is worth noting that the relationship between these two entities was only clarified a few years later in 2020, following the publication of a new regulation (No. 047-2020). An analysis of the mandates showed that SENACIT oversees the promotion of policies pertaining to the scientific and innovation development in Honduras and coordinates the different stakeholders. The IHCIETI is the technical agency responsible for the design and implementation of strategies, policies and programs for scientific research, and technological development, such as a national plan for STI through which it will establish the country's priorities on the topic.

Quite a few of the STI systems in SICA follow this two-pronged approach. Guatemala is another example: its National Council for Science and Technology (CONCYT) formulates the STI policy and its associated budget (as well as approves international technical cooperation) whereas its National Secretariat for Science and Technology (SENACYT) executes and implements the policy decisions of the former. El Salvador recently created two key institutions in its STI ecosystem, establishing a Vice-Ministry of Science and Technology in 2009 and a National Council for Science and Technology (CONACYT) in 2013, both attached to the Ministry of Education. In this case, a much more specific role can be identified at the ministerial level since its objective is to develop an information and communication technology policy for schools in the country. The Council executes national policies on scientific and technological development and encourages innovation.

As explained above, Costa Rica has a slightly different arrangement, in that it involves a ministry and a scientific council, yet the similar two-headed structure remains. MICITT generates and promotes compliance with public policies on science, innovation, and technology while the National Council (CONICIT) executes policies and finances research and development.

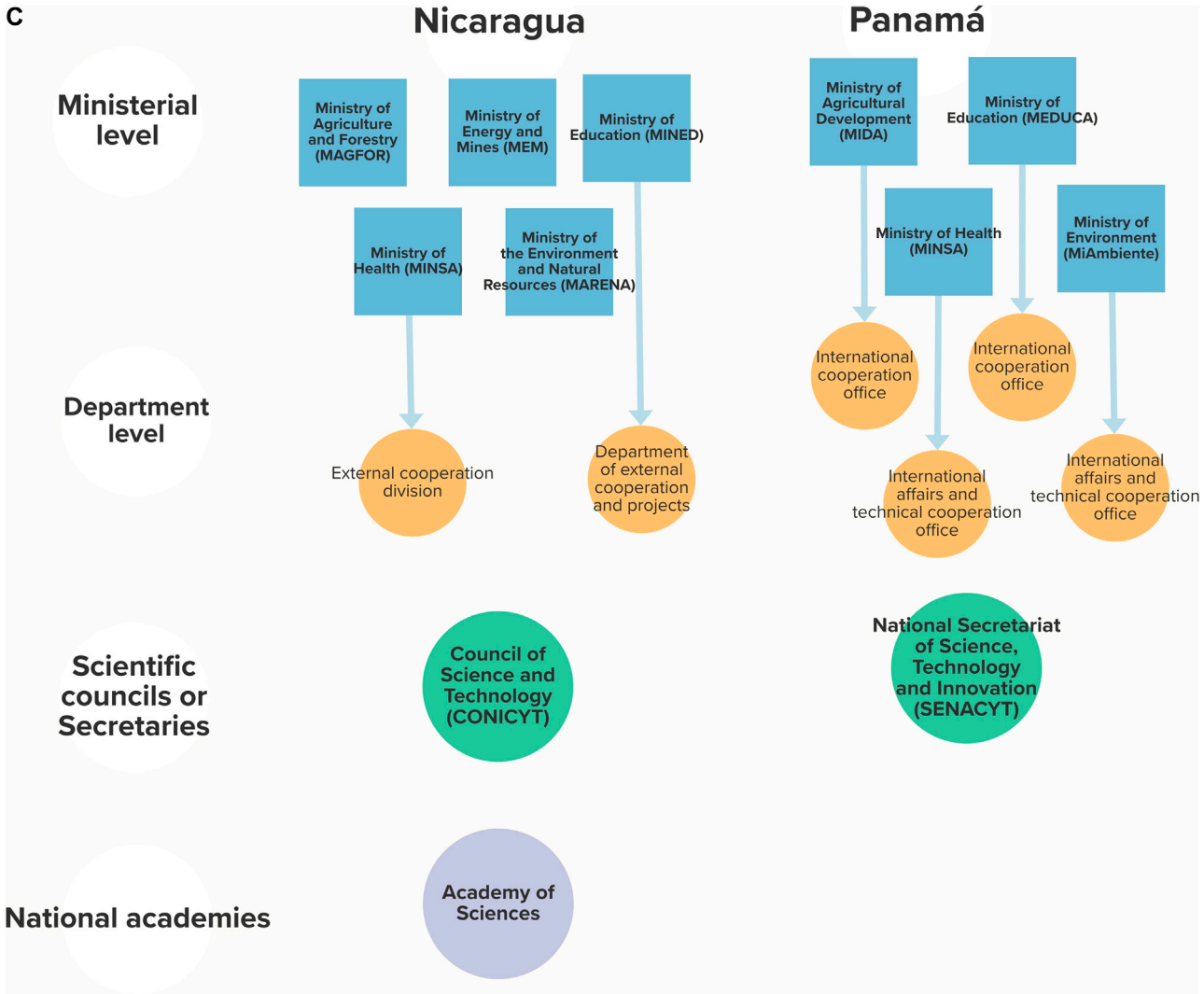

FIGURE 1 | *Continued*.

A detailed analysis of the mandates revealed that each country carries out different activities for the international engagement of its scientific councils. El Salvador's CONACYT focuses on promoting research, technology transfer and R&D through international alliances. Panama's SENACYT centers their attention on strengthening global cooperation, through signing agreements with international organizations. Guatemala created a national scientific and technological information system to facilitate relations with international networks. CONICIT (Costa Rica) focuses on financing scholarships abroad and IHCIETI (Honduras) seeks financing for the National Plan for Science, Technology, and Innovation.

National Academies

National academies are also an important actor in the STI ecosystems which usually finances all or parts of their operations through public funding. They play a critical role at the national level but also internationally (e.g., through the informal connections of their members or formal connections to overseas networks) and may play a role in informing the science diplomacy agenda of their country[6], as is the case in the United States[7] or South Africa (Maphosa, 2019) for example.

Four of the SICA countries have official national academies (Costa Rica, Guatemala, Honduras and Nicaragua). Neither El Salvador nor Panamá have national academies (though for the latter its "Panamanian Association for the Advancement of Science" seems to be acting as a substitute), which may represent an important gap for the coordination of the scientific community and research activities (both domestic and international) of these countries.

[6]https://www8.nationalacademies.org/pa/projectview.aspx?key=51726

[7]Diplomacy for the 21st Century: Embedding a Culture of Science and Technology Throughout the Department of State. Washington, D.C.: National Academies Press, 2015.https://doi.org/10.17226/21730.

TABLE 1 | Year of creation and sources of financing of National Academies in Central America.

	Costa Rica	El Salvador	Guatemala	Honduras	Nicaragua	Panamá
National Academy	National Academy of Sciences	None	Academy of Medical, Physical and Natural Sciences	National Academy of Sciences	Academy of Sciences[a]	None
Year of creation	1992	*Not applicable*	1945	1983	2005	*Not applicable*
Source of financing	Central Government	*Not applicable*	Public University	Central Government	Nonprofit Civil Association	*Not applicable*

[a]*Note that Nicaragua's Academy of Sciences is a nonprofit and not publicly funded, but it is included here for reference*

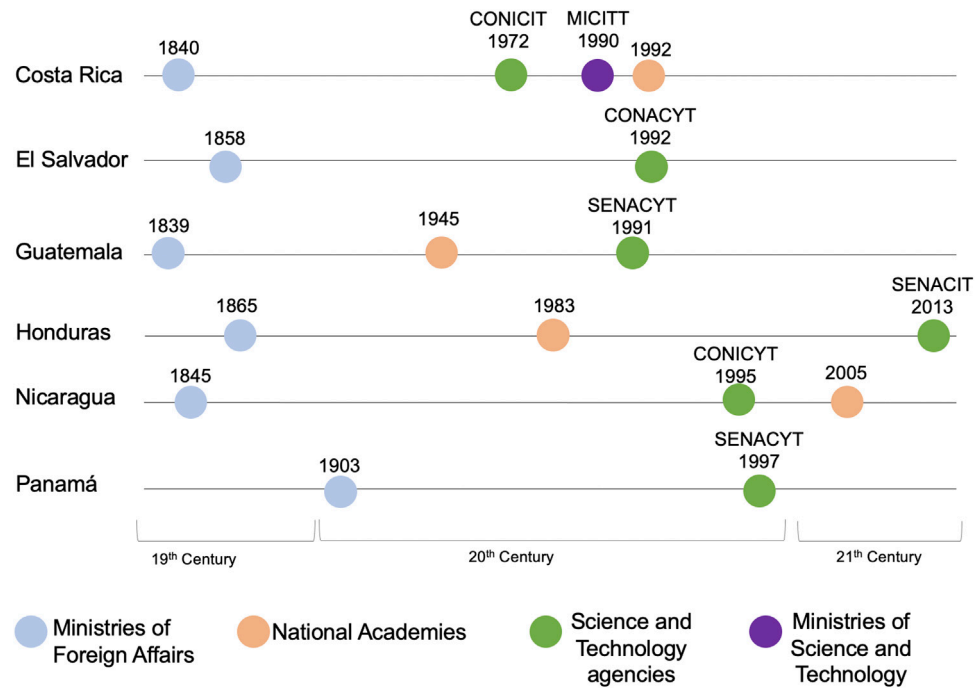

FIGURE 2 | This timeline shows the dates of creation of the six SICA countries' Ministries of Foreign Affairs (in blue) and Science and Technology (in purple) as well as their respective S&T agencies (in green) and national academies (in orange). It only depicts the current institutional setting and hence does not include agencies that have been removed or replaced over time. In addition, other ministries which have a portfolio connected to scientific issues (see *Results*) are not featured here so as not to overcrowd the timeline.

As can be seen in **Table 1**, these national academies have been created at different times in history, from 1945 (Guatemala) all the way to 2005 (Nicaragua). This research also found important differences from country to country in terms of funding and mandates, among others.

In terms of sources of funding, according to documents and budgetary information publicly available on these various entities' websites, the Costa Rican academy is financed directly by the Ministry of Science and Technology (MICITT), while the Honduran one is sponsored by a Presidential Department attached to the Secretariat of General Coordination of the Government (SCGG), providing it with a strategic location for the provision of scientific advice in the decision-making process of the country. On the other hand, Guatemala's national academy was created by a public university (San Carlos University) and in Nicaragua, it is a non-profit civil association.

The statutes of the national academies of Costa Rica, Guatemala, and Honduras include establishing cross-border scientific collaborations through agreements with foreign institutions, as well as organizing and participating in international scientific conferences and forums to position their countries on the international scientific scene. Whether this was done in direct consultation with the Ministry of Foreign Affairs of their respective country is beyond the scope of this paper but would be a valuable next step. Gual Soler (2020) identified that the Costa Rican MoFA and the National Academy of Sciences have articulated efforts to link diplomatic practice to local research around natural disaster prevention, biotechnological development, amongst others.

All SICA national academies (with the obvious exception of El Salvador) are members of the regional Inter-American Network of Academies of Science. Guatemala, Honduras and Nicaragua are members of the InterAcademy Partnership (IAP), an international network of more than 140 academies of science, medicine and engineering from around the world[8]. Surprisingly, Costa Rica is not a member of IAP.

A Dichotomy Between Diplomacy and Science

In order to contextualize the evolution of science and diplomacy institutions in the region, **Figure 2** visualizes the year in which these agencies were created over time. As can be seen in the Figure, the Ministry of Foreign Affairs were mostly created in the 19th century or at the turn of the 20th century, whereas the national STI institutional infrastructure in Central America is relatively recent. The creation of these STI national bodies and institutions coincides with the period of greatest institutional innovation in the history of the region, but also with the peace and post-conflict processes experienced in the eighties and nineties (Vargas-Cullell and Duran, 2016).

Beyond the timeline, **Figure 2** provides an interesting overview of the SICA countries national institutions and further highlights the difference in the institutional hierarchy of agencies between the two realms of science and diplomacy. Diplomatic matters are always led by ministries, (which represent the highest hierarchical level of the public administration), while overarching (non-thematic) STI issues do not fall within the remit of a single coordinating ministry (with the exception of Costa Rica) but rather within secretariats, scientific councils and national academies (or are fragmented within various thematic ministries). These national agencies, while in charge of overarching STI issues, do not necessarily carry the same political and institutional weight as ministries.

This could result in an institutional "imbalance" when setting a science diplomacy agenda in collaboration with other government ministries, as scientific councils may not participate in cabinet meetings, hence their access to have the necessary communication and coordination with each of the governing ministers of the different sectors is more limited. Finally, they do not have direct access to multilateral and international forums the MoFA and other ministries usually have under their legal mandate.

This may have resulted in science still playing a limited role in the foreign policy of the region. However, it is worth noting however that the lack of an STI ministry may not be an impediment to launch strategies around science diplomacy, as Panamá demonstrated in2018[9] when it became the first Latin American country to define a national strategy promoted by the MoFA and SENACYT (Gual Soler, 2020).

DISCUSSION: TOWARDS A SCIENCE DIPLOMACY PORTFOLIO IN CENTRAL AMERICA

This exploratory research carried out a first diagnosis of the current STI institutional landscape in the SICA region, and the potential for these institutions to engage in science diplomacy. It reveals various challenges at the national and regional level, stemming from the multiplicity and disparity of institutions, and the heterogeneity of their mandates across Central America. Understanding such challenges may be helpful for countries in the region in developing meaningful strategies around science diplomacy.

The institutional landscape analysis shows that most STI national bodies and institutions in the SICA countries were created during the period of greatest institutional innovation in the region. However, this also led to a multiplicity of entities and fragmentation of roles. This may be detrimental to achieving an effective science diplomacy strategy unless complex inter-linkages are constructed via inter-ministerial tasks forces or other processes. Another challenge is the gap that exists in the institutional hierarchy of agencies between the two realms of science and diplomacy. Diplomatic matters are always led by ministries, while STI issues are fragmented in various thematic ministries and the main overarching STI portfolio is typically led by scientific councils, pointing to a potential institutional imbalance[10]. This would imply better clarifying current roles and competencies. A future study could look in more detail at interlinkages across these multiple actors to better understand how they may play a role in setting the science diplomacy agenda of the country in order to advance the countries' national needs and interests, as well as strengthen bilateral scientific collaborations (S4D4C objective 1). It would also be key to identify if and when coordination with the MoFA may play a multiplying role, especially to facilitate evidence-informed positions of the country in multilateral endeavours and global challenges (S4D4C objective 2).

A detailed analysis on the scientific council's mandates also reveals that each country carries out different activities for the international engagement of these entities. These institutions present a wide diversity in their structures and mandates across the region, which could make it more difficult for the SICA countries to address their cross-border interests or to strengthen bilateral or multilateral collaborations in STI. In addition, at a regional level, it may also impact the ability for the SICA countries to design consistent and complementary

[8]https://www.interacademies.org/network/member-academies

[9]EU Science Diplomacy. "Panama's Science Diplomacy Strategy: Current State and Future Challenges," June 29, 2020. https://www.s4d4c.eu/panamas-science-diplomacy-strategy-current-state-and-future-challenges/.

[10]It should be noted however that Panamá´s science diplomacy strategy was launched in 2018 in spite of this particular challenge.

regional policies that address common STI-related challenges. This may be an opportunity to better integrate these institutions in the regional agenda, as a means to improve bilateral relations (S4D4C objective 4), address cross-border interests and better project the region internationally in STI (S4D4C objective 5).

Despite these challenges, science diplomacy represents an opportunity for countries in Central America and for the region as a whole. Future research is crucially needed to better define the necessary institutional capacity and cross-institutional linkages required for the deployment of a successful science diplomacy strategy. This is particularly salient in the context of emerging countries in light of some of their institutional challenges. Moreover, in-depth case studies of the SICA countries will be necessary to explore whether their respective institutions are working as intended to enable the integration of science within foreign policy agendas, if coordination is effective and how their activities are perceived internationally. This would require dedicated interviews, surveys, and ethnographic field work. Going beyond the state's institutions, it would also be key to investigate the role of non-governmental and decentralized institutions in the region for science diplomacy, such as local governments, universities, nonprofits and the private sector.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

MJ-S and J-CM both contributed to the literature review, defining the research and early versions of the text; MJ-S collected the data, prepared the database, made the figures and table, and drafted the first manuscript; MJ-S and J-CM both contributed to the subsequent writing and editing of the manuscript.

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Science Diplomacy for Climate Action and Sustainable Development in Latin America and the Caribbean: How Important Is the Early Career Perspective to New Governance?

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Science diplomacy and science–policy interfaces are tools that science has to address the biggest challenges that the world faces today. The scientific community needs to develop the capacity to bring this scientific knowledge to society and decision-makers for the purposes of new governance of the Earth System and thus a more resilient society. Climate change is one of the most challenging issues the world is currently facing, and the Latin America and Caribbean (LAC) region is highly vulnerable to its consequences, as it is expected to exacerbate environmental, social, and economic problems in the LAC region. In this context, and as an emergency call to address the climate crisis with the latest available science in the region, this paper collects a series of examples of the progress, best practices, gaps, challenges, and solutions. We do so from the perspective of Early Careers Researchers (ECRs) and undergraduate and graduate students, highlighting what we are doing to engage scientists in society–policy–science interaction for the sustainable development agenda and climate action in Latin America and the Caribbean.

Keywords: science diplomacy, sustainable development, LAC region, science-policy interface, ECRs

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INTRODUCTION

Science diplomacy is a growing cross-disciplinary field. The United Nations Educational, Scientific, and Cultural Organization (UNESCO) defines science diplomacy as a tool to achieve foreign policy but also to promote peace and sustainable development using science as a process and communication (UNESCO, 2017). The Madrid Declaration on Science Diplomacy defines science diplomacy as a series of practices between science, technology, and foreign policy (S4D4C, 2019). However, the New Frontiers in Science Diplomacy publication defines three important dimensions of it: science in diplomacy, diplomacy for science, and science for diplomacy (The Royal Society- AAAS, 2010).

All of these definitions have in common that science diplomacy focuses on scientific solutions, expertise, resources, and tools towards an international effort to solve international problems, including biodiversity loss, climate change, environmental degradation, and public health issues (Haynes, 2018; Tolentino, 2020).

In the climate arena, international agreements such as The Paris Agreement are the best examples of international collaboration for concrete climate actions. The Intergovernmental Panel on Climate Change (IPCC) is the scientific body of the United Nations and the World Meteorological Organization (WMO) charged with examining and assessing the latest data and state of knowledge to do with climate to aid in making science-based decisions. During climate negotiations, science diplomacy is a push for climate decision-making. (Tolentino, 2020).

For sustainable development, science diplomacy supports countries efforts to achieve the Sustainable Development Goals (SDGs) using science and advanced technology for the common good of humanity to address cross-border cooperation and partnership in sciences and technology (Saner, 2015). The SDGs need multilateral solutions and South–South Cooperation to create knowledge and build a bridge between diplomats and scientists (Echeverria et al., 2020).

But what role do ECRs play in science diplomacy when it comes to addressing global issues? To achieve this issue, we must first define ECRs—Who are We?.

Early Careers Researchers—Who Are We?

A person who is in the first stages of research can be referred to as an Early Career Researcher (ECR) or Early Stage Researcher (ESR). An ECR in academia is often defined in terms of someone active in research in the first 5 years following Ph.D. completion. (Agnes Bosanquet et al., 2016).

According to the Economic and Social Research Council (ESRC) of the United Kingdom, ECR stages are doctoral, immediate postdoctoral, and transition to an independent researcher (Economic and Social Research Council, ESRC, 2016). Other research agencies suggest that an ECR is someone within 8 years of the Ph.D. degree or a student or scholar who is at the undergraduate, graduate, or postgraduate level (depending on national context) up to 3 years post-Ph.D. (International Standing Conference for the History of Education, ISCHE, 2021).

While there is not a specific or agreed-upon definition, it remains necessary to identify ECRs (Bazeley, 2003). In general, the ECR definition depends on the context, purpose (grants, internships, scholarships, predoctoral or postdoctoral trainees, new faculty, jobs, congress, training, and courses), and other factors (for example age, level of educational training, or work experience). However, "labelling academics who have a promising but as yet unrealised research career as "young" or "new" ignores those who have come to research later in life or later in their academic career" (Bazeley, 2003).

For the purpose of this paper, ECRs will be defined as students and scholars who are at the undergraduate, graduate, or postgraduate level as well as young professionals, practitioners, and stakeholders within 10 years of their latest degree. Age will not be considered, but people younger than 40 and undergraduates will be prioritized.

Early Career Researchers in Science Diplomacy: Shaping The Future Of Governance

In recent years, science diplomacy has been developed mostly by fellows of different training, course, and workshop projects at leadership institutions and bodies in the Global North. In Latin America and the Caribbean, there are excellent examples of initiatives to develop science diplomacy for ECRs in the Americas, but more are needed (**Table 1**). There is still a route to consolidate and systematize relevant science diplomacy in the LAC region (Gual-Soler, 2020).

These programs are mostly focused on ECRs who are in doctoral programs, post-Ph.D., and transition-to-researcher career stages, and in these stages, it would be difficult for many of them to develop soft skills and understand how world governance and politics work. However a lot of them have developed highly specialized research that is predominantly positive since it can be applied to specific problems that require mostly specialized management; nevertheless, by keeping this in mind, science diplomacy opportunities for people in the earliest stages of scientific life is overlooked.

TABLE 1 | Examples of science diplomacy capacity building institutions, bodies, and training

Global *Global North institutions, bodies, and projects	LAC Region *South–South cooperation and North-South cooperation
● American Association for the Advancement of Science (AAAS)- Washington ● The World Academy of Sciences (TWAS) ● The International Institute for Applied Systems Analysis (IIASA) ● The International Network for Government Science Advice (INGSA) ● Earth System Governance Project ● Future Earth ● The European Union Science Diplomacy Alliance by the European Leadership in Cultural, Science and Innovation Diplomacy (EL-CSID), ● Inventing a shared Science Diplomacy for Europe (InSciDE), and ● Using Science for/in diplomacy for addressing global challenges (S4D4C) projects. ● SciTech DiploHub, the Barcelona Science and Technology Diplomacy Hub	● The Science Diplomacy for public managers of Latin America (Bolivia, 2017) ● The South-American Workshop on Government Scientific Advice (Argentina, 2017) ● The Inter-American Institute for Global Change Research projects and initiatives as Science, Technology, Policy (STeP) fellowship program ● The Ibero-American Program of Science and Technology for Development (CYTED) ● The Latin America and the Caribbean Open Science Forum (CILAC in Spanish) ● The São Paulo Innovation and Science Diplomacy School (InnSciD SP) ● Fellowship program of science-policy interface in Mexico City

In the undergraduate stage, many students are part of increasingly cross-disciplinary careers and are concerned with the challenges of the next decades, not just from a scientific view but also from that of new worldwide governance. They want to address the most challenging problems, such as climate change, and are looking for inclusive spaces, even if they are not senior researchers yet.

A great example is the 2030 Agenda and the Paris Agreement, which have objectives to mobilize ECRs globally through activism. Nevertheless, it is still difficult for ECRs to have a direct influence on, or be empowered in, the decision-making and diplomacy processes. The roles of ECRs will depend on the mechanisms that exist to foster their participation in each country.

In the case of SDG 13 Climate Action of the 2030 Agenda, one of its specific objectives is to promote mechanisms to increase capacity for climate change in the least developed countries and small island developing States, with a particular focus on women, youth, local and marginalized communities (United Nations, 2015). Then ECRs from the region, mainly from the Caribbean, should have a particular place of climate and sustainable development action in the LAC region.

In 2018, during the second Forum of the Countries of Latin America and the Caribbean on Sustainable Development of ECLAC, the first parallel event promoted and led by youth in science (undergraduate and graduate ECRs), called Interdisciplinary Science for the knowledge Economy and fulfillment of the SDGs, was held to promote the importance of youth.

ECRs from countries such as Mexico, Chile, Colombia, Peru, Venezuela, and Brazil were involved, and representatives of governments, civil society, and other stakeholders were invited. There, a statement was read on how science and cooperation should be in the region for sustainable development. This was accompanied by a previous survey, where 50 young people in science from the region participated.

One of the important findings of the survey was that the young people who participated think that their governments do not invest enough in science. Another important finding was that one of the greatest challenges faced by youth in science is the lack of capacity building. Remarkably, 97% of survey participants agreed that youth are important for sustainable development. They noted that in order to influence decision-makers, they must carry out cross-disciplinary research and get directly involved in projects that have sustainable development as their axis. By doing so, they leave behind the idea of conducting research only in a specific area and instead show a preference for a more holistic vision. However, when they were asked whether they had participated in high-level events for decision-making and diplomacy, the response was 75% negative; for the 25% who answered yes, only 7.1% had participated more than five times.

As an event outcome, then it is imperative that the number of scientists increases in the region. This can occur at scientific research centers, and also via capacity building at the regional level, to increase cooperation between countries and boost those with the greatest deficiencies. Indeed, south-south cooperation is a key to finding regional solutions. "Within the 2030 Agenda framework, it is essential to position natural sciences and social sciences in a joint way to achieve solutions in Latin American countries with a cross-disciplinary vision, where scientific-environmental character and high social purpose are crucial" (ECR Parallel Event LAC RFSD, 2018).

In 2019, some ECRs helped create the first Youth Forum LAC 2030; previous activity of the third Forum of the Countries of Latin America and the Caribbean on Sustainable Development of ECLAC. There, for the first time, an important number of ECRs in Natural sciences at the undergraduate, masters, and recent undergraduate levels throughout Latin America were involved in a process for review of prioritized Sustainable Development Goals (SDGs). They brought a regional and youth perspective, highlighting the SDG 13 Climate Action, making it different from previous events, which featured little ECR participation from Natural sciences in the LAC region.

Because of their participation, some of the ECRs recreated similar processes at their respective national levels, including the Nationally Determined Contributions (NDC) processes in 2020, where ECRs in Natural Sciences, Natural Resources Management, Biology, Earth Sciences, and Environmental Engineering Sciences led the hard negotiation process and the incorporation of the ECR component into NDC updates. Women at the Early Career Stage in Mexico, Costa Rica, and Colombia led important NDC topics such as the ocean, adaptation, youth, and gender on climate action. These processes also were of interest to other regions, UN bodies, governments, and, of course, other ECRs in the Global South and Global North.

Another important success was the ECR participation in the official delegations at the UN Climate Change Conference (COP25), where ECRs supported their delegations in negotiations. The delegations from Mexico, Costa Rica, and Chile featured ECR participation, and they supported complex negotiation on IPCC reports and science highlights as well human rights, capacity building, and article six negotiations. Finally, an important success was the adherence of Mexico and Costa Rica to an Intergovernmental Declaration on Children, Youth, and Climate Action (CERI, 2019). This process of adherence was led by young women at an Early Career Stage, which should mean a great step towards ECRs participation in climate governance and gender equality in science.

These best practices motivated the development of the first program for Latin American early-careers, mid-careers, and late-careers/senior climate scientists interested in climate negotiations. This project is currently being developed by the Latin American Network of Atmospheric Sciences and Meteorology, RedLAtM, which is an independent network led by ECRs. (RedLAtM, 2021). The purpose will be to develop science diplomacy skills, understanding international, regional, and national complexity and how to start a process for evidence-based policy formulation with the most available science in the climate sciences arena.

In March 2021, the second part of Interdisciplinary Science for the Knowledge Economy and fulfillment of the SDGs, the importance of youth in science, was part of the fourth Forum of

the Countries of Latin America and the Caribbean on Sustainable Development of ECLAC. The goal was to promote a space for dialogue and brainstorming where ECRs could be in dialogue, express their opinions, and build routes of action for the monitoring of the 2030 Agenda. The primary participation was ECRs from Venezuela, Mexico, Chile, Ecuador, Puerto Rico, and Peru. The three planetary crises, "climate change, biodiversity loss, and ecosystems degradation", the post-covid green recovery, the importance of vaccine diplomacy, and the role of ECR in the fight against covid-19 in the LAC region were addressed. (ECR Parallel Event LAC RFSD, 2021).

In April 2021, the "Early Career Scientific Youth in the incidence of the update processes on NDCs in Latin America" parallel event was held at the CILAC 2021 forum, with the participation of ECR from Mexico, Costa Rica, Colombia, and part of the government and academic sectors of Peru and Chile. This event was led by ECRs to facilitate peer networking and emphasizing the role of ECRs in updating and implementing the NDCs. Another topic was to discuss whether the NDCs had the best available science to achieve greater climate ambition in the region, highlighting the importance of ECR leadership in the negotiation and governance processes. This space was the first of its kind for the open dialogue of ECRs and NDC processes in the region. (ECR Parallel Event CILAC, 2021).

Finally, it is worth acknowledging the efforts of other youth networks in science, such as the YESS (Young Earth Scientists System) Community, who, with the collaboration of other ECR networks on the global level, brought the opportunity to incorporate ECRs into the IPCC reviews. In that effort, a total of 27 ECR reviewers from Chile, Colombia, Argentina, Brazil, Peru, and Uruguay contributed to the Second Order Draft (SOD) of Working Group I (WGI November 2019-May 2020) and Working Group II (WGII July 2020-January 2021) of the sixth Assessment Report process (AR6). (YESS Community, 2021).

In March–April 2021, *Hub ciencia emprende*, a project led by ECRs, had the first significant online open course for ECRs in LAC Region on science–policy interface,s where ECRs from the region could understand what is science diplomacy and science–policy interfaces. The course was conducted in Spanish. (Hub Ciencia Emprende, 2021).

DISCUSSION AND CONCLUSION

The ECRs are involved not only in the scientific aspect but also the social justice, the environmental movement, and the new governance breaking structural inequalities. Nevertheless, there are not enough places to participate due to limited spaces in decision making and science diplomacy and a lack of mechanisms to engage them, a lack of sufficient experience, and a lack of knowledge of how policy and diplomacy work. Collaboration with mid-careers scientists, late-careers scientists, and diplomats is needed to address it. "New generations of scientists need to be trained and must be involved in decision-making and policy processes better known as the science-policy interface." (ECR Parallel Event LAC RFSD, 2018).

It is visible that ECRs are doing science diplomacy work according to their experience, limitations, and knowledge. Although it is desired that people in their mid and late careers who have more scientific skills are those who can influence decision-making based on the best available science; ECRs are reaching towards spaces for participation. We are helping to begin a contrasting dialogue and co-create a science–policy interface as a process that also democratizes science, helps people to create resilience, and builds solid science diplomacy in the LAC region.

ECRs are creating professional support networks and sharing best practices and experiences among peers. The role of these youth networks around the LAC region, as well as the different youth movements, should be incentives for governments to invest in youth as agents of change. (ECR Parallel Event LAC RFSD, 2018).

The gaps identified so far are the lack of support that exists both financially and in terms of capacity building on science diplomacy and science–policy interface for people in the early stages. It is important to mention that all of the efforts previously shared had no specific financial support and have been achieved thanks to the volunteerism and commitment of the ECRs. These situations are a negative indicator, as, without greater support in the future, these spaces could be lost.

Also, some of the challenges that ECRs face, is that part of the scientific community does not accept these practices as science activities or practices that help their professional development, both academic and work; nevertheless, science diplomacy and science-policy interface are components of science to achieve scientific research, scientific cooperation, science policy, and governance for sustainable development.

Incorporating the ECRs in science diplomacy, international negotiations, and science policy is crucial for a new regional integration, consolidating Latin American and Caribbean diplomacy and bridging the scientific gaps between the North and South. Thanks to the fact that the majority of ECRs are pursuing interdisciplinary careers, they can understand and interact with other research areas in subsequent studies applied to global agendas, thus helping their governments and international governance to solve problems of an international nature, such as climate change.

It is important to note that the ECRs, mainly from Earth Sciences and Health Sciences, are in a learning period, studying and investigating the most relevant findings that compromise life on Earth, and they should be the ones leading environmental and social change. Further, researchers must learn to navigate the policy-making system in order to promote the application of their research in policy development (Burton et al., 2019).

Having science diplomacy training at the beginning of a scientific career could help embrace new views and opportunities for people in science, and contribute to new job creations. This would have to be analyzed with the science policy of each country. This helps us build the

capacity for science diplomacy—and not only in terms of scientific research. This also includes helping to avoid unemployment rates in the science fields that exist in the LAC region, acquiring tools at the early stages of scientific careers, and finding out how to apply this knowledge for innovation and new governance.

Finally, some of the ECRs come from backgrounds of cultural and gender diversity, which encourages other minorities to be involved in this formulation of public policies based on evidence, such as the indigenous people, women, people with disabilities, afro-descendants, neurodiverse people, and other youth sectors: groups of the population that in Latin America and the Caribbean are highly vulnerable. This important topic will help to address intergenerational, environmental, and social justice in the LAC region.

The ECRs have proven to be aware of the social, environmental, and economic needs of the region, using science as a tool for sustainable peace in our region. Unfortunately, as long as funding is not available, participation cannot be fully formalized, and we could lose the science diplomats of the future in the region.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because it is part of surveys and personal information is protected by law. Requests to access the datasets should be directed to Latin American Network of Atmospheric Sciences and Meteorology, redlatm.contacto@gmail.com, just public results can be shared. Personal information such as name, age, contact information are protected.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

I, PC-R declare all information here is valid and I gather all this information as a part of Executive Committee from Latin America Network of Atmospheric Sciences and Meteorology.

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