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REVISTA BRASILEIRA DE GESTÃO E DESENVOLVIMENTO REGIONAL
V.22, N°4, Edição Especial 2026 | Taubaté/SP - Brasil | ISSN 1809-239x

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PARADIGMAS DE DESIGUALDAD: MUJERES EN LA CIENCIA EN MÉXICO, CUBA Y EL SALVADOR

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Received: 03/29/2026
Accepted: 07/11/2025

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ABSTRACT

The participation of women in science and technology in Latin America presents a fundamental paradox: while the region exhibits one of the highest rates of female enrollment in higher education STEM (Science, Technology, Engineering, and Mathematics) programs worldwide, this massive representation does not correspond to equitable presence in the upper echelons of academic and leadership careers (UNESCO, 2021). This review article argues that, although challenges such as the "leaky pipeline" and the "glass ceiling" are cross-cutting, historical trajectories and institutional responses are deeply contingent on the political and social contexts of each nation. Through a narrative and comparative analysis of three paradigmatic cases—Mexico, Cuba, and El Salvador—the different models of female insertion into science, their impacts, and resistance strategies are examined. The emergence of organized and transnational responses, such as the Congresses of Researchers of the SNII and Ibero-America, is specifically analyzed as an explicit strategy to combat these systemic inequalities. It is concluded that, despite national differences, the transformation of the scientific ecosystem towards equity requires public policies that address structural and cultural barriers, and the disproportionate social impact of women-led research in the region is recognized.

Keywords: Women in science. Gender and science. Latin America. Systemic inequality. Science policies. Collective agency.

RESUMEN

La participación de las mujeres en la ciencia y la tecnología en América Latina presenta una paradoja fundamental: si bien la región exhibe una de las tasas más altas de matrícula femenina en programas de educación superior en STEM (Ciencia, Tecnología, Ingeniería y Matemáticas) a nivel mundial, esta representación masiva no se corresponde con una presencia equitativa en los escalafones superiores de la carrera académica y de liderazgo (UNESCO, 2021). El presente artículo de revisión argumenta que, si bien los desafíos como la "tubería con fugas" (*leaky pipeline*) y el "techo de cristal" son transversales, las trayectorias históricas y las respuestas institucionales son profundamente contingentes a los contextos políticos y sociales de cada nación. A través de un análisis narrativo y comparado de tres casos paradigmáticos —México, Cuba y El Salvador—, se examinan los distintos modelos de inserción femenina en la ciencia, sus impactos y las estrategias de resistencia. Se analiza específicamente el surgimiento de respuestas transnacionales y organizadas, como los Congresos de Investigadoras del SNII y de Iberoamérica, como una estrategia explícita para combatir estas desigualdades sistémicas. Se concluye que, a pesar de las diferencias nacionales, la transformación del ecosistema científico hacia la equidad requiere políticas públicas que aborden las barreras estructurales y culturales, y se reconoce el impacto social desproporcionado de la investigación liderada por mujeres en la región.

Palabras-clave: Mujeres en la ciencia. Género y ciencia. América Latina. Desigualdad sistémica. Políticas científicas. Agencia colectiva.

INTRODUCTION

The global scientific landscape has progressively recognized the importance of diversity, equity, and inclusion as catalysts for innovation and excellence. In this context, Latin America emerges as a region of particular interest and contradiction. According to data from the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2021), the region has one of the highest rates of female graduates in STEM programs globally, exceeding 50% in many countries. However, this massive representation in the formative stages does not correspond to an equal presence in the upper echelons of the academic and industrial career. This phenomenon, documented globally as the "*leaky pipeline*", where female talent is lost at every professional level, and the "glass ceiling", which prevents access to leadership positions, reveals that barriers have mutated from being explicit (prohibition of admission to university) to structural and cultural (implicit biases, work overload) (Alper, 1993).

This review article aims to go beyond the mere quantitative description of these gaps. Our central argument is that the trajectories of women in Latin American science are not homogeneous, but are deeply shaped by the political, economic and social context of each nation. To illustrate this thesis, a narrative and comparative analysis of three paradigmatic cases that represent a spectrum

of development models and state intervention is used: Mexico, a paradigm of quantitative progress driven by university expansion that coexists with systemic inequality; Cuba, a case of explicit state empowerment that has not eradicated the glass ceiling; and El Salvador, a scenario of resilience and action from civil society in a context of structural deficit.

Subsequently, the emergence of a transnational and organized response —the SNII and Ibero-American Congresses of Researchers— is analyzed as an explicit and mature strategy of collective agency to combat these inequalities. Finally, cross-cutting challenges are discussed, and the disproportionate social impact of women-led research is highlighted, concluding that strengthening women's leadership is not only a matter of justice, but a strategic necessity for the sustainable development of the region.

MEXICO: A PARADIGM OF QUANTITATIVE ADVANCEMENT AND SYSTEMIC INEQUALITY

Mexico's trajectory illustrates a model where the expansion of the public education system, particularly after the 1950s, allowed for unprecedented quantitative progress in the incorporation of women into science. The path was opened by pioneering figures at the end of the nineteenth century, such as the physician Matilde Montoya Lafragua, who in 1887 not only obtained her degree after an arduous legal and media battle, but also symbolized the rupture with a legal and social framework that excluded women from higher education (Tuñón, 1997). Throughout the twentieth century, the presence of women in science classrooms became normalized and, eventually, became the majority in disciplines such as biology, chemistry, psychology and medicine.

However, this numerical parity did not automatically translate into equity. From the second half of the century, a persistent and structural gap became evident. This phenomenon manifests itself in two main ways. First, horizontal segregation, which channels women into areas considered an extension of their maternal or caregiving role, such as microbiology, pediatrics, or nutrition, while their presence is less in physics or engineering (Suárez-Díaz, 2015). Second, the glass ceiling, which makes it difficult for them to rise in the academic hierarchy.

The creation of the National System of Researchers (SNI) in 1984, although it formalized the recognition of scientific work, also served as an accurate thermometer to measure these inequalities. Systematic analyses of the SNI confirm that, although women represent more than 50% of the members at the initial levels (Candidate and Level I), their proportion falls to less than 30% at Level III, the one with the highest prestige, economic recognition and convening power (Cetto; Vessuri, 2005; De La Cruz; Ronderos; Duarte, 2019). This quantitative evidence became the catalyst for collective organizing. Faced with a system that seemed to perpetuate inequality through evaluation criteria that often reward uninterrupted career trajectories and a productivity that does not consider gender realities, Mexican researchers have moved from individual denunciation to proactive political action.

CUBA: STATE EMPOWERMENT AND THE PERSISTENCE OF THE GLASS CEILING

The Cuban case represents a different model, where the advancement of women in science is the direct and explicit result of a state policy sustained since the triumph of the Revolution in 1959. The revolutionary project was based on social transformation, and for this purpose, it declared science and technology as pillars of national development. At the same time, transformative policies were implemented that prioritized universal literacy, free access to higher education, and the massive incorporation of women into productive work as a revolutionary duty (Valdés, 1995).

The results of these policies were quantitatively impressive. Women not only achieved parity in university enrollment but also came to constitute the majority in key disciplines for the national project, such as medicine, biology, chemistry and psychology. This phenomenon has been fundamental to the success of strategic sectors, such as biotechnology and public health, where the workforce is predominantly female and has achieved international recognition (Álvarez, 2001; Paho, 2018).

However, this numerical success coexists with significant contradictions that reveal the complexity of cultural change. Despite their massive presence in the ranks of university research and teaching, Cuban women scientists face a glass ceiling that hinders their access to positions of greater decision-making power. A lower proportion of women have been documented in positions as university rectors, management of top-level research institutes or in academies of sciences, where

leadership is still predominantly male (Sanz, 2010). This situation explicitly demonstrates that, while state political will can effectively remove barriers to entry, the transformation of organizational cultures and implicit power structures is a slower and more complex process. “Machismo” as a cultural norm persists and manifests itself in an overload of work for women, who must comply with the “triple shift”: paid work, domestic chores, and study or research, which often limits their time and ability to move up (Santana, 2016).

EL SALVADOR: RESILIENCE AND ACTION FROM CIVIL SOCIETY

At the other extreme is El Salvador, where the trajectory of women in science has historically been marked by profound structural limitations. Unlike Mexico and Cuba, the development of the national scientific system has depended largely on isolated initiatives of the public university, private universities and international cooperation, without a robust and sustained public policy in science and technology. However, the participation of women in scientific work is not a recent phenomenon. From the end of the nineteenth century and for much of the twentieth century, women were incorporated mainly in areas such as medicine, pharmacy and education, almost always linked to the university and teaching environment. These contributions remained invisible due to the absence of mechanisms for registration, dissemination, and institutional recognition, as well as persistent gender biases (Calles, 2014, Las Melidas, 2019).

In recent decades, a positive and paradoxical phenomenon has been observed in El Salvador. Various studies show a sustained increase in the participation of women in higher education and in several scientific careers, particularly in the health sciences, biology and chemistry; however, this increase does not imply a general reversal of existing gender inequalities in the scientific system (Calles, 2014; Trejo, *et al*., 2023). This advance in access to higher education has not translated into equivalent participation in scientific research or in academic leadership spaces. The available evidence indicates that the presence of women continues to be concentrated in university teaching and social sciences, while in strategic areas such as engineering their participation remains limited, with approximately 19% of graduates, one of the lowest rates in the region (ECLAC, 2023). Likewise, the small number of female researchers with doctoral training restricts women’s access to larger-scale

projects, competitive funding and decision-making positions, configuring more fragile professional trajectories. This scenario expresses a marked phenomenon of “leaky pipelines”, associated with precarious working conditions, institutional instability and a disproportionate burden of family and care responsibilities, factors that directly affect the permanence and progression of women in the Salvadoran scientific career (Argueta; Ramos, 2020).

Added to this scenario is a process of academic migration forced by structural precariousness, in which many women scientists choose to continue their training or develop their professional careers abroad due to the limited availability of job and research opportunities in the country, which makes it difficult to consolidate sustainable scientific trajectories at the national level (Argueta; Ramos, 2020). In this context, resilience acquires a particular significance, not only as an individual capacity for adaptation, but as a collective strategy for permanence in a scientific ecosystem characterized by institutional weakness and low state prioritization of science. The trajectories of Salvadoran women scientists have been sustained through self-training, the diversification of functions – teaching, applied research and community work – and the articulation of academic support networks promoted by universities and civil society, which have made it possible to make inequalities visible, strengthen capacities and generate spaces for professional accompaniment. These dynamics confirm that collective agency constitutes a structural resource for the permanence and professional development of women in Salvadoran science, particularly in contexts where scientific policies with a gender focus are limited or non-existent (Calles, 2014).

TRANSNATIONAL RESPONSES AND COLLECTIVE AGENCY: THE ORIGIN AND EVOLUTION OF RESEARCHERS’ CONGRESSES

In the face of these shared structural challenges, collective organizing has emerged as a fundamental strategy for agency and advocacy. The most paradigmatic and consolidated example in the region is that of the SNII and Ibero-American Congresses of Researchers. Its origin dates back to 2014, with the founding in Mexico of the Association of Women Researchers of the SNI-CONACYT. The explicit objective of the First Congress, held that same year at the Benemérita Universidad Autónoma de Puebla (BUAP, 2014), was to create a space to combat the isolation, invisibility and

lack of recognition that many academics felt in their institutions.

This purpose was consolidated in the II Congress (2015, University of Guadalajara), but it was the III Congress (2016, Autonomous University of Nuevo León) that marked a strategic turning point by expanding its call to all of Latin America. This transformation responded to the need to overcome national borders, promote synergy and identify the common challenges and perspectives faced by women scientists in the region. The evolution of these congresses reflects a maturity in the struggle: the focus shifted from mere scientific dissemination to the advocay in public policies of science and technology, promoting knowledge of the various national realities and strengthening collaboration networks.

The consolidation of this initiative was palpable at the V Congress (co-organized by the UAT and the BUAP), which brought together more than 2,000 researchers and 1,000 graduate students from 22 countries, establishing itself as a leading forum for the exchange of knowledge and experiences. Discussions focused on crucial topics such as gender mainstreaming in science, female leadership in academia, and strategies to increase the visibility and impact of women-led research. Congresses thus transcend the nature of an academic event to become a political instrument that combats invisibility, creates collaboration networks and, crucially, builds a collective voice capable of demanding fair evaluation systems and equitable working conditions (Association of Women Researchers of the SNII, 2025).

THE SOCIAL IMPACT OF WOMEN-LED RESEARCH

Beyond the internal struggle in academia, a rigorous analysis reveals that women-led research in the region is characterized by a distinctive and powerful focus on social impact and local problem-solving. Their contributions are fundamental in strategic areas for the sustainable development of the region.

In public health and health sovereignty, the health sector is one of the fields where the impact is most palpable. In Cuba, the development of the biotechnology sector, a pillar of national sovereignty, has been driven by teams with high female participation. A fundamental milestone was the development of the VA-MENGOC-BC® vaccine against meningococcal B, the first of its kind worldwide, in whose creation scientists played a leading role (Talavera, 2017). Recently, during the COVID-19 pandemic, the leadership of

female figures was crucial in the design and production of the Abdala and Soberana vaccines, positioning the country at the forefront of regional immunization (Torres, 2021). In Mexico, research has focused on endemic pathologies with a high burden of disease. Dr. Susana López Charretón, a virologist at UNAM, has made seminal contributions to the understanding of rotavirus, and her research has been fundamental for the development of new vaccine strategies (López, 2018). In El Salvador, although without a comparable health sovereignty strategy, the contribution of women in the field of public health has been significant from medicine and the training of human resources; the career of Dr. María Isabel Rodríguez stands out, whose work in medical teaching, health management and the formulation of public health policies constitutes a benchmark of the female impact in the strengthening of the national health system, developed in a context of institutional limitations and the absence of a consolidated scientific policy (Calles, 2014).

In environmental sustainability and resource management, women-led environmental research is characterized by an ecosystem and participatory approach. In Mexico, Dr. Patricia Balvanera of UNAM is an authority on the study of ecosystem services, quantifying the contribution of biodiversity to human well-being and providing a scientific basis for conservation policies (Balvanera *et al*., 2012). In El Salvador, women-led environmental research includes work in marine ecology and coastal biodiversity; among the outstanding contributions is that of Johanna Segovia, a marine ecologist who has led studies on the biodiversity of black coral reefs (Segovia, 2023), the record of marine species echinoderms (Ramos; Segovia, 2021) and the integration of ecological knowledge in mangrove conservation and conservation processes in Central America (Díaz-Ferguson, *et al*., 2024), to mention some studies of her vast work as a research scientist. In addition to being recognized for its contribution to the fulfillment of sustainable development goals.

Finally, in social sciences and social transformation, the impact is perhaps more profound. In Mexico, scholars such as Marta Lamas not only added women to existing studies but also reconfigured the field by introducing categories such as gender and patriarchy (Lamas, 2007). In El Salvador, research has been intertwined with social intervention, generating knowledge for action on issues of gender-based violence and historical memory (Silva, 2010). In Cuba, social researchers have acted as mediators, analyzing the gaps between the discourse of equality and everyday practices (Martínez, 2012).

DISCUSSION: COMPARATIVE SYNTHESIS AND CROSS-CUTTING CHALLENGES

The comparative analysis of these three countries reveals that, although the paths are different, the structural challenges are deeply transversal in Latin America.

Table 1 summarizes the key differences and similarities.

Table 1 | Comparison of Models of Women's Participation in Science

Dimension	Mexico	Cuba	El Salvador
Role of the State	University expansion, but weak and reactive gender policies.	Explicit and centralized empowerment as a pillar of the revolutionary project.	Dependent on international cooperation; without robust politics.
Main Barrier	Systemic inequality and biases in evaluation systems (SNI).	Persistent glass ceiling and "triple shift" despite access.	Forced academic migration due to structural precariousness of the scientific system
Primary Form of Agency	Collective organization to influence public policies (Congresses, networks).	Individual and collective bargaining within state structures.	Resilience and self-organization from civil society and universities.
Social Impact	High, especially in social sciences and biomedicine.	Very high, key to sovereignty in health and biotechnology.	High, focused on community problem solving

Source: Authors' elaboration based on the narrative review.

A universal challenge, which underlies all the barriers mentioned, is the disproportionate burden of unpaid work. The "double shift" or "triple shift" (scientific work and domestic and care responsibilities) continues to be one of the main causes of burnout, stress, and the abandonment of promising careers (Cabella; Genta, 2018). This overload not only reduces the time available for research, writing, and networking, but also reinforces stereotypes that associate women with the role of primary caregiver, delegitimizing their ambition and commitment to science. Added to this is the persistence of hostile or gender-indifferent work climates, where harassment and micro-machismo are daily barriers.

The emergence and consolidation of the SNII and Ibero-American Congresses of Women Researchers represents the most forceful and organized response to these common problems. Their very existence is explicit proof that Latin American and Ibero-American women scientists have gone from being subjects of study to active agents in the transformation of their own ecosystem, building a shared regional agenda.

CONCLUSION AND FUTURE PROSPECTS

The participation of women in science in Latin America is a complex narrative of struggles, advances and persistent challenges. The cases of Mexico, Cuba, and El Salvador explicitly demonstrate that there is no single trajectory, but that the results are deeply shaped by the political context: from Cuban-driven empowerment to the fight against systemic inequality in Mexico and resilience in El Salvador. Despite their differences, they all share the need to overcome structural barriers such as the glass ceiling and the double shift.

The analysis carried out allows us to conclude that the knowledge generated by women in the region, with its marked focus on social impact and the resolution of local problems, is indispensable for sustainable development. Strengthening their leadership is not only a matter of gender justice, but a strategic necessity to build more equitable, resilient and prosperous societies.

To advance towards this goal, several lines of action and future research are proposed:

1. **Transformative Public Policies:** It is imperative that the countries of the region implement science and technology policies with a gender perspective. This includes not only quotas, but also the reform of evaluation systems (such as the SNII in Mexico) to equitably value mentoring, teaching, community work, and diverse trajectories. In addition, universal care policies (childcare, mandatory paternity leave) that alleviate the burden of the "double shift" are crucial.
2. **Strengthening of Networks and Mentoring:** The success of initiatives such as the Congresses of Women Researchers must be replicated and sustained. Supporting mentoring networks, both formal and informal, is key to retaining talent and guiding new generations of female scientists.
3. **New Areas of Research:** Future studies should focus on quantifying the economic and social impact of the work of Latin American women scientists. Likewise, a deeper comparative analysis with other regions of the Global South and intersectional studies that analyze how gender intersects with race, class, and geographic location are required to shape different experiences within science.

Ultimately, the transformation of the Latin American scientific ecosystem towards full equity is a shared responsibility that requires the commitment of governments, academic institutions, civil society, and the scientific communities themselves. Only in this way will it be possible to unleash the full potential of the talent available in the region to face the great challenges of the 21st century.

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FUNDAÇÃO DE APOIO À PESQUISA,
TECNOLOGIA E INOVAÇÃO





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