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SOCIO-CULTURAL AND INSTITUTIONAL BARRIERS TO WOMEN'S PARTICIPATION IN STEM

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ABSTRACT :

Background: Though there have been major advancements in terms of female students participating in STEM education in India, the numbers drop drastically with rising academic levels and even more so in case of employment and research positions. This phenomenon is known as "leaky pipeline" and poses a major concern for gender equality within the realm of STEM education and employment. Objective: The present review article analyses the sociocultural and institutional barriers affecting the participation, retention, and progression of women within STEM education and employment in South India. Methods: The systematic review of secondary sources like AISHE reports (2020-2024), Government of India's Ministry of Education publications, policy documents and research papers related to gender and STEM in India has been undertaken for the purpose of the analysis. Thematic synthesis has been employed to understand the barriers and recurring patterns. Results: Women make up 44% of the STEM graduates in India but only 18%-30% of the STEM professionals, while their numbers fall below 20% for faculty and research leadership positions. Major barriers include: (1) Sociocultural factors concerning gender roles and domestic duties; (2) Institutional discrimination and mentorship shortage; (3) Workplace culture and bias; (4) Intersectional discrimination related to caste, class, and rural/urban. Conclusion: In order to fix the leaky pipeline, the approach that needs to be taken includes mentorship programs, clear policies on promotions, gender sensitivity in institutions, and special attention towards women belonging to the marginalized sections of society. Policy recommendations based on empirical evidence have been made in order to encourage women in STEM in India's Viksit Bharat@2047 vision.

Keywords: Women in STEM, Gender inequality, Socio-cultural barriers, Institutional discrimination, Intersectionality, South India, Career advancement, Leaky pipeline

1. Introduction

There has been considerable progress in the inclusion of Indian women in STEM education over the last decade. The All India Survey on Higher Education (AISHE) 2023–24 indicates that women account for 44% of total STEM enrollment in India at undergraduate, postgraduate, and doctoral levels as compared to 38.4% in 2014–15 (Ministry of Education, 2024). Moreover, in the Science stream, the number of women enrolled (29.8 lakh) exceeds the number of men enrolled (27.4 lakh) at the undergraduate level (Ministry of Education, 2024; Education for All in India, 2026). Nevertheless, the increasing numbers of women enrollments in STEM education conceal a serious problem: the declining representation of women in higher levels of study, STEM research, and management in STEM organizations (Chattopadhyay, 2026; Gulati et al., 2026).

The process of losing women in STEM careers at different stages due to a collection of barriers has been described as the "leaky pipeline" (Chattopadhyay, 2026; Smile Foundation India, 2025). Although women represent over 40% of all STEM graduates in India, the share of women in the STEM workforce makes only 20–30%, and women constitute less than 20% of scientists or faculty members in STEM research and educational institutions (Chattopadhyay, 2026; EY India, 2026). In Engineering and Technology, the situation is even more serious, since the percentage of girls enrolled in STEM at the undergraduate level in the year 2021–22 stood at merely 29.14% (Ministry of Education, 2023).

South India, including Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, and Telangana, represents one of the important regions from which the issue of gender disparity in STEM must be studied. These five Indian states boast of being highly developed in terms of education, technology, and policy innovations but gender gaps in STEM still exist, despite all the advantages. It is important to understand the nature of these barriers in the region in order to develop strategies that would be replicable elsewhere in India (Historical Evolution of Women's Access, 2026; Education for All in India, 2026).

This review paper attempts to accomplish three objectives: (1) to present the literature on the socio-cultural barriers hindering women's involvement in STEM education and occupations in South India; (2) to analyze institutional and workplace barriers for women in STEM leadership positions; and (3) to identify research gaps in the study of barriers, based on caste, class, and geography, to women's STEM careers. This article provides a holistic

understanding of the complex problems confronting women in STEM in South India through the combination of quantitative findings from national surveys and qualitative findings from previous research studies.

2. Review of Literature

2.1 Women's Participation in STEM: Global and Indian Context

Despite various policy efforts and campaigns, there is still unequal representation of women in STEM globally. According to UNESCO, women make up just 35% of STEM graduates worldwide, with a wide range of regional and discipline-related discrepancies (Smile Foundation India, 2025). The unique feature of India is that women comprise approximately 43% of STEM graduates in the country—this proportion is the highest globally (EY India, 2026; Smile Foundation India, 2025). Nevertheless, in career terms, women make up merely 27% of positions in STEM (EY India, 2026).

However, India shows another peculiar feature related to participation of women in STEM studies: although the proportion of women enrolled to STEM programs has been rising consistently, the absolute gender gap became even wider due to overall growth of enrollment (Education for All in India, 2026). For example, the number of women enrolled to five top Indian IITs more than doubled from 1,621 in 2018 to 3,247 in 2025, yet the absolute gender gap grew to 9,153 (India Today, 2026).

2.2 The Leaky Pipeline Phenomenon

The "leaky pipeline" model refers to the attrition of women from career pathways in science, technology, engineering, and mathematics (STEM) at different levels—undergraduate level to doctoral program, post-doctoral phase, faculty positions, and leadership positions (Chattopadhyay, 2026; Smile Foundation India, 2025). It has been found that women leave STEM field careers at several points—(1) transition from undergraduate to postgraduate level; (2) entry into the workforce; (3) progression to senior level; and (4) retention in leadership positions (EY India, 2026).

Regarding India, the leaky pipeline problem has been observed in engineering and technology fields. In India, between 2013-14 and 2021-22, there was a significant fall in women who enrolled in postgraduate engineering and IT programs by 43 percent (EY India, 2026). Similarly, in the case of academic medical leadership, women faculty members have increased only slightly from 24.2% in 2004-05 to 27.5% in 202

2.3 Theoretical Frameworks

There are three theories that form the basis of this review:

Intersectional Feminist Theory (Crenshaw, 1989) stresses that the gender gap cannot be considered separately from other aspects of society like caste, class, and geography. Marginalized women have an additional disadvantage which is different in nature than the one faced by privileged women (Historical Evolution of Women's Access, 2026; Education for All in India, 2026).

Human Capital Theory (Becker, 1964) states that investments in education and skills should lead to corresponding career benefits. But there is a disparity between the level of education/skills of women in STEM and career success, pointing towards the influence of some other variables (Historical Evolution of Women's Access, 2026).

Capability Approach (Sen, 1999) concentrates on the freedom of women to pursue careers they want. It explains how some structural problems hinder women from developing capabilities to use their education for a career (Historical Evolution of Women's Access, 2026).

2.4 Research Gaps

There are many drawbacks in existing literature about women in STEM in India:

- 1) too much use of national level data without taking into consideration the regional diversity;
- 2) insufficient intersectional analysis involving caste and class;
- 3) not enough attention paid to the qualitative analysis of the experiences of women in STEM;
- 4) absence of an assessment of the effectiveness of governmental policies introduced since 2020 (WISE-KIRAN, GATI, NIDHI);
- 5) insufficient emphasis on the South India region as a unique social and cultural setting (Historical Evolution of Women's Access, 2026; Education for All in India, 2026).

3. Socio-Cultural Barriers

3.1 Gender Norms and Family Expectations

Socio-cultural norms concerning the role of women in society are the most ubiquitous barriers to women's ongoing participation in the STEM field. The socio-cultural norm of women being primarily focused on their domestic duties rather than their professional life creates immense stress for women pursuing a rigorous STEM career (Chattopadhyay, 2026; Gulati et al., 2026). Research studies reveal that 'work-family conflict' is one of the biggest impediments to women advancing in their careers as STEM professionals (Gulati et al., 2026).

In South India, although there is relatively high literacy and educational level among women compared to other parts of the country, patriarchal norms about the caregiving nature of women remain prevalent (Historical Evolution of Women's Access, 2026; Education for All in India, 2026). Women

working in STEM have been subjected to immense societal pressure to sacrifice their professional life in favor of their domestic duties, especially after marriage and motherhood (Chattopadhyay, 2026; EY India, 2026).

3.2 Safety and Mobility Concerns

The fear of safety issues considerably influences the education and career prospects of women in the STEM domain. Safety issues often make it difficult for families to allow women's movement outside their premises for education and careers that involve traveling, night duty, or relocating (Historical Evolution of Women's Access, 2026; Education for All in India, 2026). It becomes even more important for the field of engineering and technology because the work of women in the field involves fieldwork, odd hour lab work, and industry placement.

In rural and semi-urban regions of South India, the issue becomes prominent due to the absence of good public transport facilities, women's hostels, and proper security measures at institutions (Historical Evolution of Women's Access, 2026). These issues mainly impact poor women because they cannot afford private transport and housing facilities.

3.3 Stereotypes and Socialization

Socialization is an important part of the development of gender roles and stereotypes, and those about intelligence and fit in STEM are developed at an early age as well. Young girls are dissuaded from learning mathematics and science and encouraged to choose more "feminine" subjects, including humanities, education, or life sciences (Ministry of Education, 2023; EY India, 2026). Despite the fact that females prevail among students of the Science program (53.3% of students), they still do not have representation in Engineering and Technology (30% of students) (Education for All in India, 2026; Ministry of Education, 2024).

These stereotypes are fostered through the actions of educators, parents, and peers, as technical aptitude is associated with masculinity (EY India, 2026; Smile Foundation India, 2025). Moreover, women, who have entered STEM, feel that they experience imposter syndrome and self-doubt in this male-oriented environment.

3.4 Marriage and Geographic Mobility

It is a usual occurrence for women in STEM fields to experience career disruptions as a result of marriage. Career disruption may involve spousal relocation, the demand that women accompany the husband to his city, as well as the prioritizing of the career of the husband above that of the wife (Chattopadhyay, 2026; Gulati et al., 2026). Different from men, women are not usually expected to relocate in order to further their careers and, in most cases, dual-career couples put priority on the husband's career (EY India, 2026).

This kind of situation is more troubling in the case of women academics, whose careers need mobility. Those who refuse to relocate are likely to have few career prospects and stagnate professionally (Gulati et al., 2026; Smile Foundation India, 2025).

4. Institutional and Workplace Barriers

4.1 Institutional Discrimination and Bias

Formal policies aimed at ensuring gender equity in institutions often reinforce discrimination against women in the field of STEM disciplines. In a study conducted to understand the issues facing the leadership of academic medical institutions in India, the problem of "Institutional Culture" was identified, wherein women faculty members were found to face exclusion from decision-making and networking opportunities (Gulati et al., 2026).

Gender discrimination may take various forms including (1) preference for men in recruitment and promotions; (2) discrimination in allocation of resources and funding; (3) exclusion from research activities; (4) gender stereotypes in terms of teaching and administrative work burden; and (5) inadequate recognition of women's contributions (Chattopadhyay, 2026; Gulati et al., 2026; Smile Foundation India, 2025).

In the case of universities in South India, women academicians claimed that committees assessing promotion cases tend to undervalue the research accomplishments of women candidates especially if there is a gap in their publications due to maternity leave or other family reasons (Gulati et al., 2026).

4.2 Lack of Mentorship and Sponsorship

Mentorship has always been considered an important aspect of career growth; however, women working in STEM domains have reported a lack of mentorship support (Chattopadhyay, 2026; Gulati et al., 2026; Smile Foundation India, 2025). This lack of mentorship arises due to a lack of role models among the senior faculty members in STEM (EY India, 2026).

In addition, there is a lack of effective mentorship for women from disadvantaged groups such as Scheduled Castes, Scheduled Tribes, and those from a rural background (Historical Evolution of Women's Access, 2026; Education for All in India, 2026). This disadvantaged group of women faces unique barriers which other privileged women may not face and thus require mentors who can represent their interests (Historical Evolution of Women's Access, 2026).

4.3 Workplace Culture and Hostile Environments

The workplace culture of STEM organizations is often built around masculine values which may be intimidating and hostile to women. These are some of the common issues that have been pointed out through research: (1) dominance of male informal networks controlling access to opportunities; (2) gender-based microaggressions and sexism; (3) sexual harassment; (4) working hours which are too long to take care of children; and (5) the absence of gender-sensitive policies (Chattopadhyay, 2026; Gulati et al., 2026; Smile Foundation India, 2025).

Women working in STEM institutions feel alienated and underappreciated in predominantly male environments (Gulati et al., 2026; EY India, 2026). The combined effect of such experiences results in women quitting STEM jobs in search of better work environments or leaving their career altogether (Chattopadhyay, 2026; Smile Foundation India, 2025).

4.4 Leadership Representation Gap

The marginalization of women from leadership roles creates a vicious circle. If women do not have a sense of identity in positions where decisions are made, they would have lesser chances of aspiring to take up leadership roles and greater chances of feeling that STEM institutes are unwelcoming to them (EY India, 2026; Gulati et al., 2026).

From data collected in Indian medical institutions, it was seen that in 2022-23, 27.5% of the total faculty were women, and even lesser were there in senior leadership roles like department heads, deans, and directors (Gulati et al., 2026). The same scenario prevails at engineering institutes, research labs, and technology firms of South India (Historical Evolution of Women's Access, 2026; Education for All in India, 2026).

5. Intersectional Barriers: Caste, Class, and Geography

5.1 Caste-Based Disadvantages

Caste continues to be an important yet understudied aspect of women's participation in STEM fields. Caste discrimination is combined with gender discrimination faced by women from Scheduled Castes (SC) and Scheduled Tribes (ST) (Historical Evolution of Women's Access, 2026; Education for All in India, 2026). An investigation of the higher education access in STEM areas in India showed that "social identity" is a very significant predictor of STEM enrollment and graduation, controlling for economic status (STEM Beyond Reach, 2025).

The experiences of SC/ST women in South Indian Universities include caste-based discrimination by their peers and faculty, social isolation, and lack of institutional support (Historical Evolution of Women's Access, 2026). Such experiences result in higher drop-out and poor retention of marginalized women, despite the presence of reservation policies aimed at increasing access (Historical Evolution of Women's Access, 2026; Education for All in India, 2026).

5.2 Class and Economic Barriers

Economic status is one important factor that impacts women's ability to receive quality education in STEM and pursue STEM careers. Although AISHE indicates some improvements in terms of access to STEM for poorer economic quintiles in round 71 and 75 NSS, there still remain huge disparities (STEM Beyond Reach, 2025). For poor women, these factors create barriers for their access: (1) lack of means to afford expensive coaching to pass entrance exams; (2) willingness to attend government colleges due to low fees, though the number of seats is small; (3) pressure to join workforce early to assist family; and (4) lack of money for higher studies/research (STEM Beyond Reach, 2025; Historical Evolution of Women's Access, 2026).

The rise of private universities has increased social discrimination in accessing quality education and training. Rich women have access to private unaided colleges with better facilities and job prospects whereas poor women are forced to join government colleges (STEM Beyond Reach, 2025; Historical Evolution of Women's Access, 2026).

5.3 Rural–Urban Disparities

Geographical location poses considerable hindrances for women belonging to rural areas. Issues facing women of rural areas include: (1) lack of access to good STEM education in schools, which causes them to be poorly prepared for competitive examinations; (2) lack of knowledge about STEM careers and scholarships; (3) patriarchal environment limiting their movement and education; and (4) lack of infrastructure (transport facilities, hostels, safety) in rural education institutions (STEM Beyond Reach, 2025; Historical Evolution of Women's Access, 2026; Education for All in India, 2026).

For rural women who move into cities to pursue STEM education and careers, the following additional hindrances exist: (1) difficulty in cultural adaptation; (2) language problems; (3) social alienation; and (4) discrimination based on rural background (Historical Evolution of Women's Access, 2026; Education for All in India, 2026).

5.4 Intersectional Framework

Intersectionality helps us understand that there is no addition of obstacles but rather multiplication. A Dalit woman coming from a poor, rural background in Tamil Nadu will have qualitatively different hurdles compared to an upper-caste woman who comes from an urban, middle-class

background in the same state (Historical Evolution of Women's Access, 2026; Education for All in India, 2026). Initiatives that approach the issue of “women in STEM” as a homogeneous entity fail to tackle the problems of those who are most disadvantaged, thus reproducing inequality among women (Historical Evolution of Women's Access, 2026).

6. Discussion

6.1 Synthesis of Barriers

In this review, there are identified four different categories of barriers influencing participation of women in STEM in South India which are interconnected:

1. Sociocultural barriers: Gender expectations, family pressures, fear, stereotyping, and marriage-mobility restrictions.
2. Institutional barriers: Discrimination, biases, lack of mentoring, negative working environment, and leadership gaps.
3. Intersectional barriers: Caste, class, and geographical barriers that interact with gender barriers.
4. Gap in implementation of policy: Poor implementation of gender-equality policies at institutional level.

These barriers exist on various levels: individual, familial, institutional, and societal and create the ecosystem of exclusion that can be overcome only by means of multifaceted approaches (Chattopadhyay, 2026; Historical Evolution of Women's Access, 2026; Gulati et al., 2026).

6.2 The Paradox of High Enrollment

India's relatively high percentage of women participation in STEM (44%) exists along with their lower participation rate in STEM jobs (27%) and in STEM leadership positions (less than 20%) (EY India, 2026; Ministry of Education, 2024; Gulati et al., 2026). Such a phenomenon may indicate that challenges face individuals mostly at the retention and advancement stage and not at the entry stage. Women gain entry into STEM education but leave at various points in the career due to accumulating disadvantages (Chattopadhyay, 2026; EY India, 2026).

The notion of the “leaky pipeline” seems relevant for such a process, but this notion might be misleading because it does not recognize its structural nature. Women are not just “leaking out” but being pushed away by organizations due to discriminatory policies and practices (Chattopadhyay, 2026; Smile Foundation India, 2025). Thus, the problem can be described as “structural exclusion” and not “individual attrition.”

6.3 South India as a Distinct Context

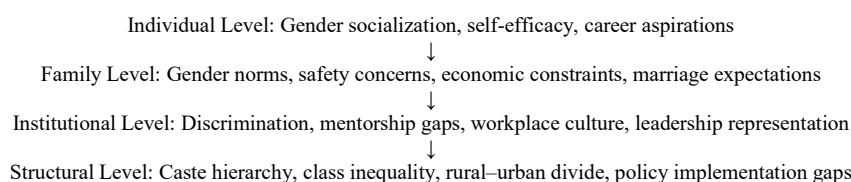
The southern states of India provide an interesting case for the study of gender disparities in STEM. These states show:

- higher levels of literacy among women and greater educational achievement than the average levels nationally;
- long history of women's education and women's universities;
- progressive social reform movements;
- significant gender disparities among STEM leadership (Historical Evolution of Women's Access, 2026; Education for All in India, 2026).

This phenomenon implies that education alone will not help resolve the problem. Institutional culture is resistant to change despite relative progress in socio-cultural environment (Historical Evolution of Women's Access, 2026; Gulati et al., 2026).

6.4 Proposed Framework

Based on this review, I propose an **Intersectional Structural Barriers Framework** for understanding women's participation in STEM in South India:



It is important to note that the barriers in each level complement each other in many ways. Any form of intervention requires addressing of multiple levels, and not just individual empowerment or organizational policy alone (Historical Evolution of Women's Access, 2026; Gulati et al., 2026).

7. Conclusion and Recommendations

7.1 Summary of Findings

In this review, I have highlighted the findings concerning the socio-cultural and institutional barriers impeding women's involvement in STEM in South India. They include the following:

1. Women make up 44% of all STEM graduates but are only 20-30% of STEM professionals, less than 20% of faculty members, and research leaders (Ministry of Education, 2024; EY India, 2026; Gulati et al., 2026).
2. Socio-cultural barriers (gender roles, family pressures, safety issues) greatly impact the options and mobility of female workers (Chattopadhyay, 2026; Historical Evolution of Women's Access, 2026).
3. Institutional barriers such as discrimination, a lack of mentoring, and an unfriendly workplace environment result in attrition and stagnation (Gulati et al., 2026; Smile Foundation India, 2025).
4. Intersectionality (caste, class, geography) further compounds the gender-based barriers, causing distinct experiences for disadvantaged women (Historical Evolution of Women's Access, 2026; Education for All in India, 2026).
5. Current policies have helped increase access but not retention and advancement (EY India, 2026).

7.2 Policy Recommendations

Based on these findings, the following evidence-based recommendations are proposed:

Institutional Level:

- Develop mentorship programs that include mentorship of women researchers and academics.
- Establish unbiased and transparent promotion/recruitment systems with gender-based audits.
- Develop gender-responsive work policies such as parental leave and flexible working hours.
- Conduct gender audits and publish diversity statistics regularly.
- Improve the implementation of POSH (Prevention of Sexual Harassment) policy.

Societal Level:

- Launch awareness campaigns challenging gender stereotypes in STEM.
- Engage families and communities in supporting women's STEM careers.
- Promote visibility of successful women scientists and engineers as role models.
- Address safety and mobility concerns through improved public transportation and institutional security.

7.3 Directions for Future Research

This review identifies several gaps requiring further investigation:

1. Longitudinal studies which trace women's career paths from undergraduate education to their retirement to find the turning points in their career.
2. Qualitative studies on the experiences of women belonging to the marginalized groups (SC/ST, rural, poor) in STEM field.
3. Policy assessment studies that assess the effectiveness of government policies such as WISE-KIRAN, GATI and NIDHI in improving retention and advancement.

4. Intersectionality studies which look at the interplay between caste, class and geography with gender to produce different outcomes.
5. Cross-state studies in the South Indian states.

7.4 Alignment with Viksit Bharat@2047

Gender parity in the STEM fields is critical for India to fulfill its ambition of being an advanced and innovative country by 2047. Inclusion of women in STEM would: (a) increase the pool of researchers and innovators; (b) diversify the perspectives on problem solving; (c) facilitate achievement of sustainable development goals (SDG 4: Quality Education, SDG 5: Gender Equality, SDG 8: Decent Work, SDG 9: Industry and Innovation); and (d) help in establishing India as a knowledge economy (Historical Evolution of Women's Access, 2026; Education for All in India, 2026).

Fixing the leaky pipeline of women's participation in STEM fields is not only about gender equality but is a necessity for the development of the nation. With a strategy that eliminates obstacles to women in STEM and creates an enabling environment, India can capitalize on its human resources and achieve Viksit Bharat@2047.

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