EPWD DISCUSSION BRIEF #1

Unchartered Waters: Tracing Women's Pathways in Male-Dominated Hardship Sectors

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AI-GENERATED IMAGE. Synthetic illustration only. No real persons depicted.

Economic Policies for Women-led Development

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Abstract

In India, women comprise just 9% of mining/quarrying workers, facing barriers like STEM gaps, unsafe sites, stereotypes, and leaky pipelines in hardship sectors (mining, oil and gas and hardcore engineering). ICRIER's EPWD launched a Podcast series, titled "Unchartered Waters", with the aim to study sectors that follow traditional workforce gender norms, where the participation of women has historically remained low, through conversations with some women who entered and navigated these sectors. The discussions were substantiated with secondary data. Both highlight demand-side hurdles (harassment, facilities gaps) and supply-side issues (childhood biases, role model scarcity). The discussion complements 2025 labour reforms with: early STEM exposure, expanded schemes, role model integration in curricula; infrastructure like safe transport, on-site amenities; public-private partnerships for hostels/day-care; diversity-sensitivity training; and digitalization/automation to create women-friendly roles in automated mining and GIS. These measures aim to fix pipelines, boost retention, and enhance sector performance and women's agency.

Keywords: *Women in mining, Hardship sectors, STEM gender gap, Female workforce participation*

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List of abbreviations

AI	Artificial Intelligence
AISHE	Annual Survey of Higher Education
ATL	Atal Tinkering Labs
BCG	Boston Consulting Group
BSR	Business of a Better World
CAMS	Comprehensive Annual Modular Survey
CBSE	Central Board of Secondary Education
CCTV	Closed-Circuit Television
CSR	Corporate Social Responsibility
EIL	Engineers India Limited
EPWD	Economic Policies for Women-led Development
GDP	Gross Domestic Product
GIS	Geographic Information System
GPS	Global Positioning System
GRC	Grievance Redressal Committee
HSE	Health, Safety, And Environment
ICT	Information and Communication Technology
IISc	Indian Institute of Science
IISD	International Institute for Sustainable Development
IIT	Indian Institute of Technology
ILO	International Labour Organization
ISRO	Indian Space Research Organisation
IT	Information Technology

JNV	Jawahar Navodaya Vidyalaya
NGOs	Non-Governmental Organizations
NIC	National Industrial Classification
NOC E&P	National Oil Company – Exploration & Production
ONGC	Oil and Natural Gas Corporation Limited
PLFS	Periodic Labour Force Survey
PwC	PricewaterhouseCoopers
STEM	Science, Technology, Engineering and Mathematics
UNESCO	United Nations Educational, Scientific and Cultural Organization
WEF	World Economic Forum
WPC	World Petroleum Council

Unchartered Waters:
Tracing Women's Pathways in Male-Dominated Hardship Sectors

Riya Khanna and Anvi Mehta

Women's participation in hardship sectors,[1] such as construction, mining and quarrying, and heavy manufacturing, remains disproportionately low, even though these industries hold considerable employment potential. In India, while the overall female workforce participation is low, the workforce is almost entirely male in certain sectors like mining and quarrying, with no representation of women. Persistent structural barriers, ranging from unsafe working environments and inadequate gender-sensitive facilities to entrenched stereotypes of "male-only" work, continue to restrict their entry, retention and progression in these fields. Moreover, women who are engaged are often confined to informal, insecure and low-paying roles. A frequently raised question, however, is why women must participate in hardship sectors.

The benefits are both social and economic. Increasing women's participation in traditionally male-dominated and hardship sectors is important to ensure that women have the same freedom as men to pursue any profession, including high-paying, physically demanding or high-risk jobs. Beyond the core principles of equality and fairness, diversity positively impacts both financial outcomes and operational performance.[2] In some hardship sectors such as mining, a study found that inclusive and diverse teams outperformed others, demonstrating 11 per cent higher adherence to production schedules and 67 per cent lower total recordable injury rates, indicating greater productivity and safer practices.[3] This underscores the importance of focused policy measures that promote safe working conditions, provide gender-responsive infrastructure, invest in skill development and create equitable opportunities for women in these high potential sectors.

The representation of women in extractive industries is low across the globe and India figures among the weakest performers. Estimates suggest that 85 per cent of all mining workers globally are men (ILO, 2021). This places extractive industries at the bottom of the industry ranking for female participation (Perks & Schulz, 2020).[4] In some developed countries such as Australia, Canada and Sweden, the gender gap is comparatively narrower although men continue to dominate the mining workforce. In India, on the contrary, the periodic labour force survey (PLFS) data indicate that only 9 per cent of the total workforce engaged in mining and other extractive industries were women in 2023-24, which is probably

[1] In the absence of a standardised definition, 'hardship sectors' are broadly understood as occupations characterised by physically intensive, hazardous or high-risk working conditions. For the purposes of this paper, hardship sectors are defined to include industries involving strenuous or unsafe work environments – most notably mining, quarrying and extractive – where the nature of work poses heightened physical and occupational risks.

[2] https://www.mckinsey.com/industries/metals-and-mining/our-insights/why-women-are-leaving-the-mining-industry-and-what-mining-companies-can-do-about-it

[3] https://www.bhp.com/news/bhp-insights/2019/10/the-gender-equation

[4] The construction sector records the lowest female participation worldwide, followed closely by the extractive industries.

at the lowest end of the spectrum.[5] Women's low participation in mining and extractive industries in India is constrained not only by the cultural and social barriers common worldwide but also by the predominance of informal employment in and the fragmented structure of the sector, which exacerbate these challenges.

Interestingly, studies indicate that gender parity in mining employment is tied to the sector's performance, the economic health of mineral-rich countries and global growth trends (IISD, 2023). Between 2012 and 2015, women's employment in mining declined worldwide due to the global slowdown following the 2008 financial crisis, rising debt, the Eurozone crisis and China's slowdown, all of which reduced mineral demand, commodity prices and investments. From 2015 onward, mining jobs rebounded as growth recovered, and women's participation also increased. Although India is richly endowed with minerals, accounting for 20 per cent of global resources, mining contributes only about 2 per cent to its GDP – minimal compared to mining-dependent economies such as Australia, where the sector accounts for around 12 per cent of GDP (Ministry of Mines, 2025). Enhancing women's participation in mining and other extractive industries could serve as a critical lever not only to boost the sector's overall performance but also to strengthen women's agency and influence within the wider economic and social landscape. This calls for a deeper examination of the underlying factors that hinder women's participation in the sector.

A key factor is the limited inclination of women toward the science, technology, engineering, and mathematics (STEM) fields, which shapes the kind of economic opportunities available to them and reinforces a self-perpetuating cycle. Women's underrepresentation in professional positions in fields such as mining, construction and extractive are closely linked to their low representation in STEM fields (Perks and Schulz, 2020). This is shaped by complex factors such as stereotypes, lack of role models, math anxiety, and perceptions of STEM as "masculine" (Hill et al., 2010; Nimmesgern, 2016). While solutions like family support, female role models, community colleges and peer networks have been proposed, their effectiveness varies across contexts and may be limited by social and structural barriers. Evidence suggests that having more female peers does not always translate into higher STEM participation (Brenøe & Zölitz, 2020). These challenges persist in professional settings, reinforcing gender gaps in STEM careers (Kansake et. al. 2021). These issues require closer examination.

To understand female workforce participation in hardship sectors, particularly in mining and other extractive industries linked to the STEM fields, ICRIER's Economic Policies for Women-led Development (EPWD) programme initiated a thematic series named *"Unchartered Waters".*[6] This theme aims to study sectors that follow traditional workforce gender norms, where the participation of women has historically remained low. Apart from secondary published sources, the study significantly draws on insights from first-hand

[5] The estimates are made following the national industrial classification (NIC) covering NIC 02-09 using the PLFS database.

[6] The phrase unchartered waters refers to *a situation that is unfamiliar, new and potentially risky because it has not been encountered or explored before.* In the context of women's participation in hardship sectors, the term captures their lived realities and the systemic challenges that continue to exist. https://www.merriam-webster.com/dictionary/uncharted%20waters

experience gathered from conversations with women who entered and navigated these sectors. The findings are used to recommend gender responsive policies that can be implemented at the organisational, government and societal levels to increase women's labour force participation in these sectors.

The following report discusses enabling factors on both the demand and supply side. To begin with, STEM fields, particularly certain engineering sectors, are still widely seen as a male-dominated domain. It is vital to acknowledge that several demand side barriers, apart from supply side issues, restrict the entry and growth of women in these fields. With this in the background, the report is divided into four sections. Section I outlines key statistical trends in women's STEM education and employment, particularly in extractive industries, to establish the baseline and map progress to day. Section II discusses the key challenges preventing women's STEM education and their progression into STEM careers, especially in core engineering fields and extractive sectors. Section III brings out key nuances and insights from discussions with women leaders in STEM-related hardship sectors on the challenges women face, the measures being taken by organisations and policy measures that can be taken to enable women's participation in these fields. Section IV discusses policy measures that need to be initiated to address specific issues that hinder increased women's participation in education and employment in hardship sectors.

1 The Paradox of Progress: Examining Women's STEM Education and Underrepresentation in the Engineering Workforce

STEM education has historically served as a foundation for innovation and global progress. In the current technology-driven landscape, shaped by advancements in artificial intelligence, biotechnology and sustainable engineering, women remain significantly underrepresented in both STEM education and employment. Globally, women began entering STEM fields in Europe and the United States in the late 19th and early 20th centuries. In India, a pivotal milestone was reached in 1944 with the graduation of the first women engineers. Since then, female participation in STEM education has expanded steadily, positioning India ahead of many global peers in terms of progression. However, equity challenges persist. Women's participation is concentrated in a limited number of disciplines and representation in STEM-related hardship sectors remains particularly low.

1.1 Educational Trends

Globally women make up only 35 per cent STEM graduates and hold only a quarter of science, engineering and ICT jobs (UNESCO, 2024). Only in nine out of 122 countries were the majority of STEM graduate's female – these were notably in Arab States, such as the Syrian Arab Republic and Tunisia.

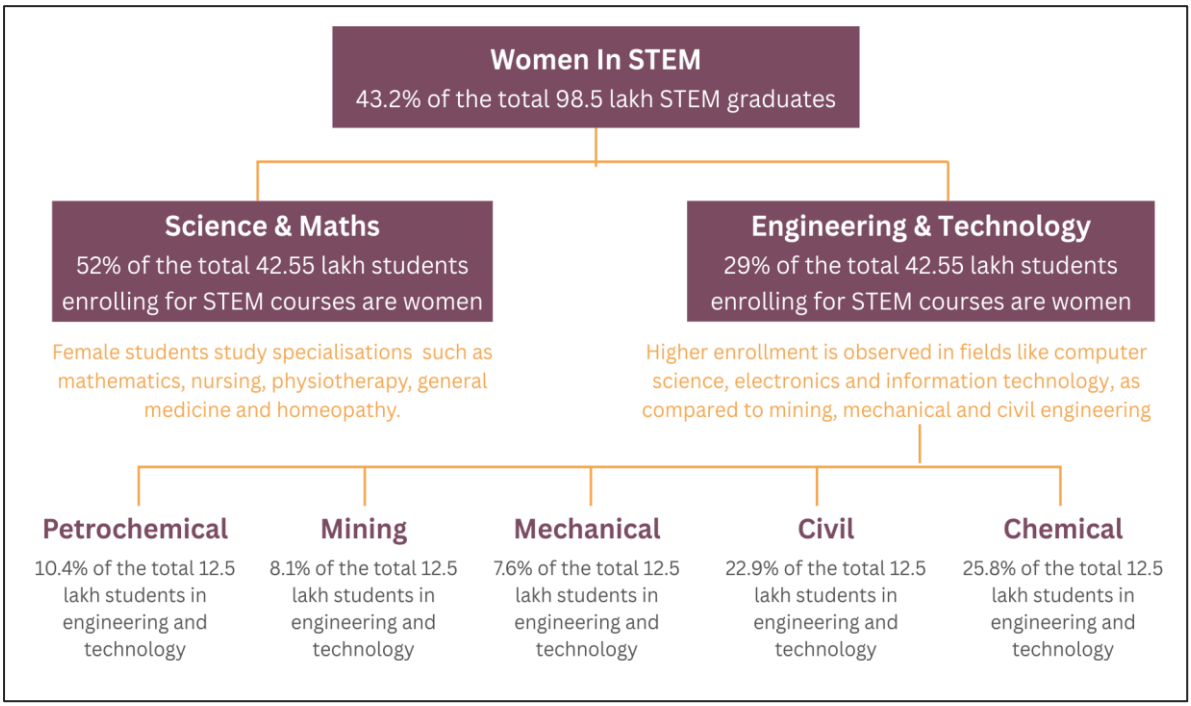
In India, the number of women studying STEM courses is higher than the global average of 35 per cent. The Annual Survey of Higher Education (AISHE) Report suggests that women's

enrolment in STEM education increased from 18.8 million in 2019-20 to 20.1 million in 2020-21. Women form 43.2 per cent of the sample across undergraduate, postgraduate, M.Phil, and Ph. D courses.

India's position looks optimistic but with a caveat. According to CAMS (2022-23), 29.1 per cent females graduated in science and technology among all graduates in India, in comparison to 37.3 per cent male graduates. As shown in Figure 1, female enrolment in STEM courses across all levels makes up to 43 per cent of the total 98.5 lakh STEM graduates. At the Class 12 level in 2023, 25.6 lakh girls passed out in science, accounting for 46 per cent of the total 56.2 lakh students. However, deeper scrutiny reveals significant disparities across different STEM disciplines. While women make up 52 per cent of students in science courses, their representation in engineering and technology courses is much lower, at only 29 per cent. In contrast, the proportion of women enrolling for undergraduate medical science courses is about 58 per cent – there are more female students studying specialisations such as nursing, physiotherapy, general medicine and homeopathy. Women have mostly been encouraged to enter fields like medicine and mathematics, which often lead to careers in teaching and research.

The numbers get even more concerning as an examination of the enrolment of female students within different engineering fields shows. Of the 29.3 per cent women enrolled in engineering and technology courses, admittance is still skewed significantly by specialisation (Figure 2). This is because certain branches of engineering, such as mechanical, civil or mining, are perceived as field-intensive and physically demanding, often discouraging female participation. These are the specialisations that are required for careers in extractive industries as well. In contrast, streams like computer science, electronics and information technology, which are seen as more office-based and less physically rigorous, attract a relatively higher proportion of women.

Figure 1: Enrolment of female students in STEM



Source: AISHE 2021-22

1.2 Employment Trends

As per the World Economic Forum's Global Gender Gap report 2024, while there are a higher number of women STEM graduates than men, only 14 per cent of these women make it into the workforce. Within STEM, women make up 33 per cent of the workforce in administrative and support services, followed by healthcare and medicine (32 per cent), education (32) per cent, government administration (31 per cent) and financial services (29 per cent). The lowest percentages in terms of inclusion of women in the workforce were seen in labour-intensive industries like construction (12 per cent) and extractive industries, including oil, gas and mining (13 per cent).

The gender gap in the Indian working population further accentuates employment trends within STEM fields. As per PLFS 2023-24, the female workforce constitutes around 35 per cent of the total worker population in India. For the current paper, the data were compiled in accordance with NIC codes 05-09, which capture employment trends in the extraction and mining industry. The trends shows that approximately only 9 per cent[7] of all workers are women and men comprise 91 per cent of the workforce, indicating a huge gender divide.

The disaggregated level of data from the PLFS 2023-24 portrays an alarming picture. Considering all the activities undertaken in the extraction and mining industry, five categories

[7] PLFS 2023-24 NIC codes 05-09

were computed, differentiated based on the nature of activities. Opencast extraction and mining[8] involve working in pits, which are either close to the surface or on the surface. As depicted in Table 1, the proportion of women in opencast mining is about 8 per cent, while 92 per cent are men. Onshore and offshore extraction[9,10] involve heavy machinery and equipment, a larger workforce and investment to extract oil and natural gas. These are mostly carried out on land (onshore) and seabed (offshore), often in international waters. There appears to be a vast difference in the proportion of men and women in this field. Astonishingly, there are no women involved in onshore activities and the proportion of women involved in offshore extraction of crude petroleum is just 3 per cent; 97 per cent of the workers were men. Activities like the extraction of onshore crude petroleum, and offshore-onshore extraction of natural gas are entirely male dominated. Underground mining involves digging for core minerals (like iron, coal, copper, lead etc.) from both deep and shallow mines. Like in the case of oil and gas extraction, mining too has a huge difference in the female and male workforce participation. Only 6 per cent of the workforce actually involved in the task of mining for ores and metals are women. Interestingly, the data reveals that mining of natural phosphates, including apatite minerals, has a female only workforce. However, this is more of an outlier than a norm in the case of mining. In contrast to mining, quarrying activities[11] (like limestone, marble, granite, salt, etc.) happen mostly on land and they are carried out closer to the surface, requiring less infrastructure and a smaller workforce. Quarrying is mostly used for sand, gravel and stones, used in construction. This activity accounts for the highest proportion of female workforce in the NIC codes mentioned above, that is, 12 per cent. The field remains male dominated, with men accounting for 88 per cent of workforce. The final category is mineral processing and other support activities,[12] which includes cleaning, sizing, washing, etc. Women constitute 10 per cent of the workforce in these auxiliary activities, while 90 per cent are men. However, women make up the entire workforce in specific activities like cleaning, sizing, grading, pulverising, compressing, etc., of coal. On the other hand, services contributing to onshore oil extraction and offshore natural gas extraction have a male only workforce.

Table 1: Employment numbers in extracting and mining industry (per cent)

Activities	Female	Male
Opencast Mining and Extraction	**8%**	**92%**
Underground Mining and Extraction	**3%**	**97%**
Quarrying Activities	**6%**	**94%**
Mineral Processing and Other Support Activities	**10%**	**90%**

Source: PLFS 2023-24

[8] https://www.sciencedirect.com/topics/earth-and-planetary-sciences/opencast-mining
[9] http://exploration-production-services.de/en/o-onshore.html
[10] https://www.sciencedirect.com/topics/earth-and-planetary-sciences/offshore-mining#:~:text=Offshore%20mining%20is%20defined%20as,United%20Nations%20International%20Seabed%20Authority.
[11] https://www.quarrying.org/about-quarrying/quarrying-explained
[12] https://www.sciencedirect.com/topics/earth-and-planetary-sciences/mineral-processing

The barriers that discourage women's participation in STEM education are amplified in the engineering fields, limiting their workforce entry.[13] Women are often discouraged from taking up jobs that require them to "rough it up" because these jobs are perceived as being unsafe and unsuitable for women who must not be "out in the sun" undertaking hardship tasks. This leads women to favour "safer" STEM branches like computer science and software engineering, which offer desk-based work In contrast, core engineering fields like mining, mechanical, civil and chemical engineering, which require on-field work, travel to remote locations that lack basic facilities and nightshifts, fail to attract enough women and remain male-dominated . This pattern is evident from employment statistics that show nearly 34 per cent of women in the engineering workforce were employed in the software and IT sectors, while core engineering fields and production roles had only 9 per cent women in 2024 (although this was a modest rise from 3 per cent in 2023) (Table 2).

Table 2: Key statistics: Indian Women Employment in Engineering

14%	34%	9%
Enter STEM Workforce	**In IT/Software**	**In Core Engineering (Civil, Production, Mining, etc.)**

Source: WEF 2024, Das 2024 and PLFS 2023-24

2 Leaky Pipelines and Locked Doors: Challenges for Women in STEM

Existing evidence highlights both demand- and supply-side constraints that curtail women's participation in STEM fields, particularly in extractive industries.[14] On the supply side, gender stereotypes and low female enrolment in core engineering and STEM programmes create a male-skewed talent pipeline. On the demand side, workplaces impose entry-level hurdles and constrain career progression, reducing women's entry and retention in these sectors. The following sections discuss these issues in greater detail.

Women's underrepresentation in high-paying professional roles is strongly linked to their lower participation in STEM fields. Although there has been in increase in the number of women enrolling for STEM courses, social stereotyping about their abilities in maths and science is still a deterrent. Without access to education and training, women often encounter fewer opportunities compared to men, reinforcing gender disparities in the workforce (Perks & Schulz, 2020).

The barriers start as early as childhood, when girls are often discouraged from pursuing careers in engineering, with societal conditioning steering them towards traditionally accepted or stereotyped professions (WEF, 2017). The third industrial revolution brought a new wave of opportunities and employment in the electrical, IT and automation fields. While this led to Indian families investing more in STEM education for their children, there was a

[13] https://www.indiaspend.com/education/nearly-50-more-women-in-higher-education-but-fewer-choose-engineering-it-940877
[14] https://www.deccanherald.com/opinion/persisting-gender-gap-in-stem-jobs-2928872

clear bias towards boys, as these professions potentially yielded good returns on investment in education by promising employment opportunities right after graduation. The financial constraints within a family can hinder girls' education in the STEM fields. Considering that the cost of delivering STEM education is higher compared to other subjects in both urban and rural parts. Hence, in situations where resources are scarce, education for the male child is prioritised over that of female child (Gaur, S. et. al., 2023).

Over time, these ingrained mindsets have created lack of self-confidence in women about their ability to enter and build careers in STEM domains. [15] Fields like engineering, particularly extractive sectors, which are outside the fields of IT and computers, are seen as incompatible with expectations around marriage, motherhood and familial duties. Women often face barriers in accessing capital and assets and, consequently, have limited entrepreneurial opportunities (World Bank Group, 2023).

The primary obstacles are cultural barriers rooted in women's safety in and around the workplace. These include concerns about night shifts, overtime, commuting across town, field visits, labour supervision, operating heavy equipment and gender-specific workplace hazards, particularly the risk of abuse by men. (ILO, 2022 and H. Abdalnour et. al., 2023). Even after securing jobs in extractive industries, cultural beliefs and social prejudices often discourage women from progressing in their careers or staying on the job.

In addition to cultural barriers, women qualifying for jobs in the extractive industries are discouraged from entering the job market due to lack of essential workplace policies like childcare, maternity leave and sexual harassment policies. Further, a visible lack of role models, especially on the strategic side of business, can also disincentivise women's participation (Women in business and management: the business case for change, 2019).

The extractive and mining sectors are often considered hazardous for women, **discouraging them from pursuing related sciences or working in the field.** Common risks include exposure to toxic chemicals and fumes, collapsing tunnels, and the use of heavy machinery in confined spaces, which can lead to hearing loss and other occupational diseases. These factors contribute to mining being one of the most hazardous occupations globally (ILO, 2022). Perks & Schulz (2020) emphasised that protective labour laws, though intended to safeguard women, often restrict their participation in extractive industries by banning night work, limiting roles deemed "dangerous" or "arduous," and restricting the use of certain machinery. Safety gear, mining equipment and sanitary facilities are not designed for women, presenting yet another obstacle to women's equal participation (BSR, 2017). In light of the new labour reforms[16] 2025, women working in night shifts might enable expanded work opportunities for them, given effective implementation.

[15] https://www.stemschool.com/articles/rich-history-of-stem-education-in-the-united-states
[16] https://labour.gov.in/sites/default/files/pib2192463.pdf

When a few women join mining companies, there are chances of them facing sexual intimidation, harassment and violence. A Canadian survey found that almost one-third of women in mining have experienced harassment, bullying or violence in their workplace in the last five years (Perks & Schulz, 2020). Even if there are dedicated departments and policies to handle discrimination and harassment, these may not be enforced, and individuals have control over investigations. It shows organisational difficulties that women in mining must face with little support from their employers. This has the tendency to create a resentful female workforce, resulting in less productive women. The ultimate effect is that women in mining will lack the courage to invite more women into the industry. This further highlights the reasons for the continuously low female participation in mining (B.A. Kansake et al. 2021)

The challenges in the STEM fields, particularly extractive industry extend beyond an unsupportive workplace and limited career progression opportunities for women; the gender pay gap is also a significant issue. According to the International Labour Organization's report, Women in Business and Management: Understanding the Gender Pay Gap (2019), there is a clear disparity in the opportunities available for men and women in full-time work. Women often take up part-time roles to accommodate the burden of unpaid care work. Additionally, the lack of affordable and adequate childcare further reinforces these part-time arrangements. With limited access to full-time opportunities, women are often excluded from key benefits, which can negatively impact their remuneration packages over time.

There is also a lack of visible role models for girls to pursue science and technology. School textbooks and popular media often portray STEM and mining and extractive fields as male-dominated and masculine fields (Kugler et. al., 2021). This not only limits girls but also shapes their self-perception from an early age. Women are often conditioned with preconceived notions about the challenges associated with engineering, which may discourage them from even seeking role models in the field. This is compounded by scepticism about entering male-dominated disciplines and organisations, and a lack of confidence in acquiring the technical skills required, often stemming from years of gender-based stereotypes and misconceptions. Women also face both subtle and overt forms of gender discrimination in these fields, along with real and perceived challenges associated with working in industrial environments. Many also internalise self-limiting beliefs, which may lead to reduced visibility in their organizations and missed opportunities for leadership and promotion.[17] The Key Global Workforce Insights report notes that 81% of Indian women in STEM have experienced gender bias in performance evaluations.[18]

Another prevalent issue that is persistent in the extractive and mining sector is the lack of women at the executive and leadership levels.[19] Take, for example, the mining industry,

[17] https://alltogether.swe.org/2024/06/inwed-women-engineers-in-india/
[18] https://www.business-standard.com/article/current-affairs/gender-bias-of-women-in-stem-in-india-high-survey-116070600300_1.html
[19] https://timesofindia.indiatimes.com/india/why-the-gender-gap-is-worse-in-stem/articleshow/101995032.cms

which has only 5 per cent female representation on the boards of the top 500 listed global companies (PwC, 2013). Only 16 of the top 100 mining companies and less than 8 per cent of the top 101 – 500 mining companies have more than one female director. (Perks & Schulz, 2020). As per Perks & Schulz, 2020, in Canada, a country with one of the highest rates of female participation in mining in the world, women are mostly employed in finance, human resources and administration, and account for a mere 5 per cent of workers at the mine site level. It is worth noting that technical mine site jobs – engineers, geologists, analysts – are higher-paying than clerical or administrative functions, where women typically congregate. Similarly, in Peru, data show that nearly half (49 per cent) of women working in mining are employed in administrative positions, while only 30 per cent work in general operations and 17 per cent work as plant personnel. In Mongolia, women work mostly in service support in the mining sector (Khan et al., 2013). The same is true of the oil and gas industry – women hold only 10 to 30 per cent of technical or field jobs (BCG and WPC, 2017).

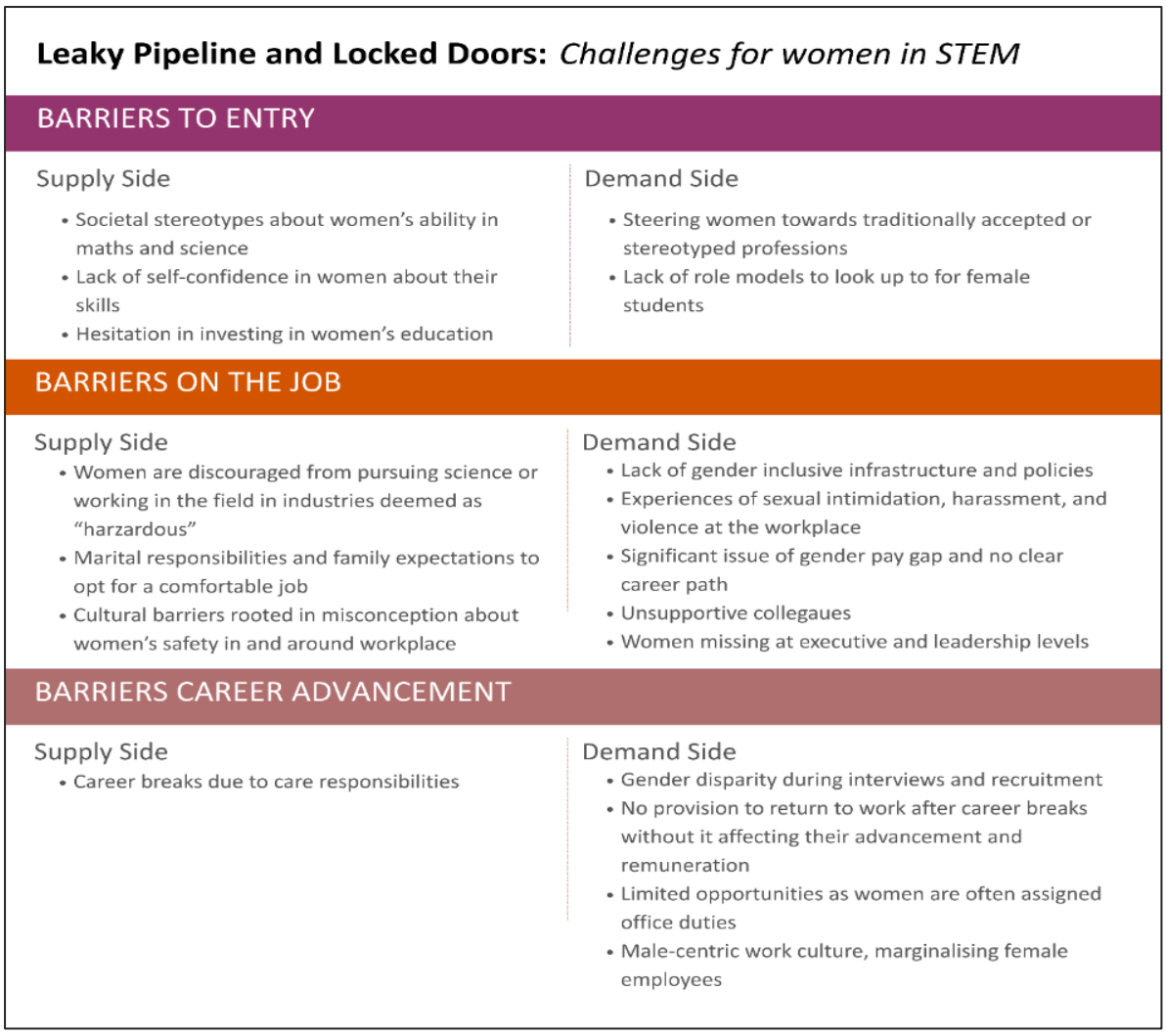
Despite the challenges in entering the ecosystem and finding opportunities, the number of women opting for extractive sector workplaces has been increasing.[20] However, this trend is rarely reflected in their career progression pathways. With limited opportunities to grow, a career break to take care of the elderly or children often makes it difficult for women to return to their positions, eventually affecting their advancement and remuneration. Nimmesgern (2016) found that the major barriers that hinder the career development of women in the construction industry are work and family balance, and lack of professionalism in human resource management. In a survey study, H. Abdalnour et. al. (2023) says, “Engineering is treated as a room full of men where female engineers must compete with men to appear to have more expertise, more experience, better imagination, more curiosity, more creative solutions, and better problem-solving skills”.

A 2022 report by the World Bank and UNESCO (Closing Gender Gaps in STEM) found that over 30 per cent of women engineers in South Asia reported being explicitly or implicitly discouraged from pursuing technical roles during recruitment. Several studies found that 42 per cent of women engineers were asked personal or family-related questions during interviews, compared with only 8 per cent of men, revealing gender disparity in interview experiences. Even when shortlisted, it was revealed that 27 per cent of female engineers are not shortlisted for interviews in core engineering sectors despite being qualified. Since engineering has often been viewed as a male dominated discipline, women are often assigned office duties. With fewer women in engineering leadership roles, the perception of engineering being a male profession gets reinforced. Furthermore, organisational cultures often evolve as male-centric and exclude or marginalise the few women who enter engineering, limiting their opportunities to thrive (Mahajan, 2025). In a study conducted by B.A. Kansake et al. (2021), the survey results indicate that rising dissatisfaction among female

[20] https://cfo.economictimes.indiatimes.com/news/job-opportunities-for-women-in-india-surge-by-48-pc-freshers-most-in-demand-report/118680210

mining stakeholders is largely due to the absence of a clear career path (25 per cent), low salary/income (10 per cent), unfavourable workload (10 per cent) and unsupportive colleagues (5 per cent). Other reasons include workplace harassment, poor incentives, and inflexible employment contracts (Perks & Schulz, 2020).

Figure 2: Barriers to women's participation in STEM fields, particularly in extractive industries



Source: Compiled from the literature

3 Insights from Conversations with Women Leaders in Hardship Sectors

The stark underrepresentation of women in core engineering fields raises critical questions about the barriers that prevent women from entering or remaining in these sectors. While enrolment data and employment trends offer a quantitative glimpse, they do not fully explain the systemic, cultural, and institutional challenges at play.

To better understand these nuances, interviews were conducted with three women leaders who have reached the top executive levels in India's leading public sector organisations in the petrochemical, construction and mining sectors (see Appendix A & B for details)**.**

These conversations reveal the real world hurdles the women dealt with, the workplace strategies their organisations adopted to support inclusion and the policy changes they believe are necessary to create a more equitable ecosystem for women in engineering. Using the valuable insights gathered from these interactions, this discussion brief summarises the challenges, best practices, and policy recommendations that must be implemented to increase women's workforce participation in engineering fields.

Insights from the discussions

3.1 Challenges for Women in Hardship Engineering Fields

Gender biases exist even in the admission process of colleges. In the 1980s, women accounted for only 2 per cent of those enrolled in fields like chemical and civil engineering, which are the foundational degrees to pursue a career in certain extractive industries; this was true even in institutions like the IIT. The college admission processes were often biased, with female students being asked to provide parental consent to join the course in the college that required participation in field research. Women were often informed of alternative career options that were safer. All three women leaders opined that, in their view, the process of admission of women in STEM at the higher education level has eased over time.

Gendered employment barriers prevent on-field work. Hazardous work is dangerous for everyone, irrespective of gender. However, conversations with the women leaders established the fact that women hesitate to opt for working on the field due to several reasons, including the lack of basic facilities like a women's washroom, discomfort working with male contractors and labourers who are not used to reporting to female managers, and safety concerns stemming from the highly disproportionate number of males on the job.

Policy and legal support for women's work in many areas is missing. Certain laws and regulations, like the Mining Act, make it difficult for women to enter the workforce. The mining act prohibits women from entering mines at night. Ironically, it was observed that the time of the day makes no difference to a miner, who work several feet below the surface of the earth.

"Before admitting me, my college asked me to bring my parents to give their consent for field studies. I was offered admission to the MSc Geology programme on the condition that I would not later refuse to participate in field studies, citing parental objections or restrictions."

- Interviewee

3.2 Organisational efforts towards building diversity in the workforce and leadership

Goal setting and proactive measures

The one insight shared by all women leaders was that corporates are increasingly taking up the onus to make inroads for women in such traditional sectors, and are taking conscious measures to increase their female workforce, at all levels. For instance, Engineers India Limited (EIL) currently has approximately 20 per cent women at the entry level, around 13 per cent women in middle management and 21 per cent at the leadership level. They have set a target of increasing the percentage of women executives to 30 per cent, and have initiated dedicated recruitment and interview campaigns to build a larger pipeline of women engineers, especially civil and construction engineers.

Inclusive Practices

Today's organisations know the importance of building diverse teams and are increasingly engaging in practices and initiatives to create a supportive ecosystem for recruitment, retention and career progression of their women engineers.

A striking feature of all the interviews was that these women leaders reported no personal experiences of gender bias in the acknowledgement of their contributions or performance, while accepting that their journeys were probably the exceptions rather than the norm. Still, they remained optimistic about an equitable organisational future, citing the younger workforce's eagerness as a foundation for better access to opportunities at the workplace. They opined that organisations could build on this talent, and especially help women enter the structured workforce, where their work and contributions will get accounted for in the economy.

Field Exposure

Field visits and fieldwork are highly encouraged, as site visits and seeing the implementation of projects are important for their career growth and promotion prospects in these fields. ONGC, for example, encourages women to gain first-hand knowledge and exposure via field visits to develop their decision-making skills.

Skill building

Apart from such regulatory changes, the participants stress the need for sensitivity. For instance, EIL's CSR activities focus on women-centric skilling and literacy programmes to make them independent. Programmes that have a social impact help long-term changes in mindsets.

Grooming Women for Leadership

While the number of women entering engineering roles is low, the number of women getting promoted to leadership positions is even lower. The need is to create a pipeline of women leaders to get their ideas across and make changes. It is imperative for women to be in decision-making roles to make an impact. All three women emphasised the need for grooming potential women leaders to take up managerial roles. This would require organisations to take proactive measures, such as including women in committees for diverse views and exposure, sending more women for field and exposure visits, and providing them equal opportunities for growth and development at the workplace. Several of these measures are already being undertaken.

Women's Agency and Self-Confidence

All interviewees underscored the importance of women "coaching" themselves to progress in STEM careers. They urged that although a nudge from the leadership might help, it is vital for women to volunteer to come forward and express their intentions to take on leadership roles. Parallelly, women should capitalise on initiatives taken by their organisations and scale up those opportunities for themselves. Encouragingly, the women leaders expressed their appreciation at witnessing the sprouting transformation, from women being hesitant in their participation to them being vocal regarding their choices and needs.

"Engineering in our sector demands hands-on expertise, especially in remote and complex project sites involving heavy construction and multiple stakeholders. Recognising this, we've dedicated recruitment for our construction division to encourage women's participation. We ensure that our women engineers are not only recruited but also exposed to site conditions – bridging the gap between design and implementation. Over the years, the endeavour has been to identify, groom, and elevate women into leadership roles, ensuring they lead from the front."
- Interviewee

3.3 Policy Insights from the Discussions

Regulatory changes

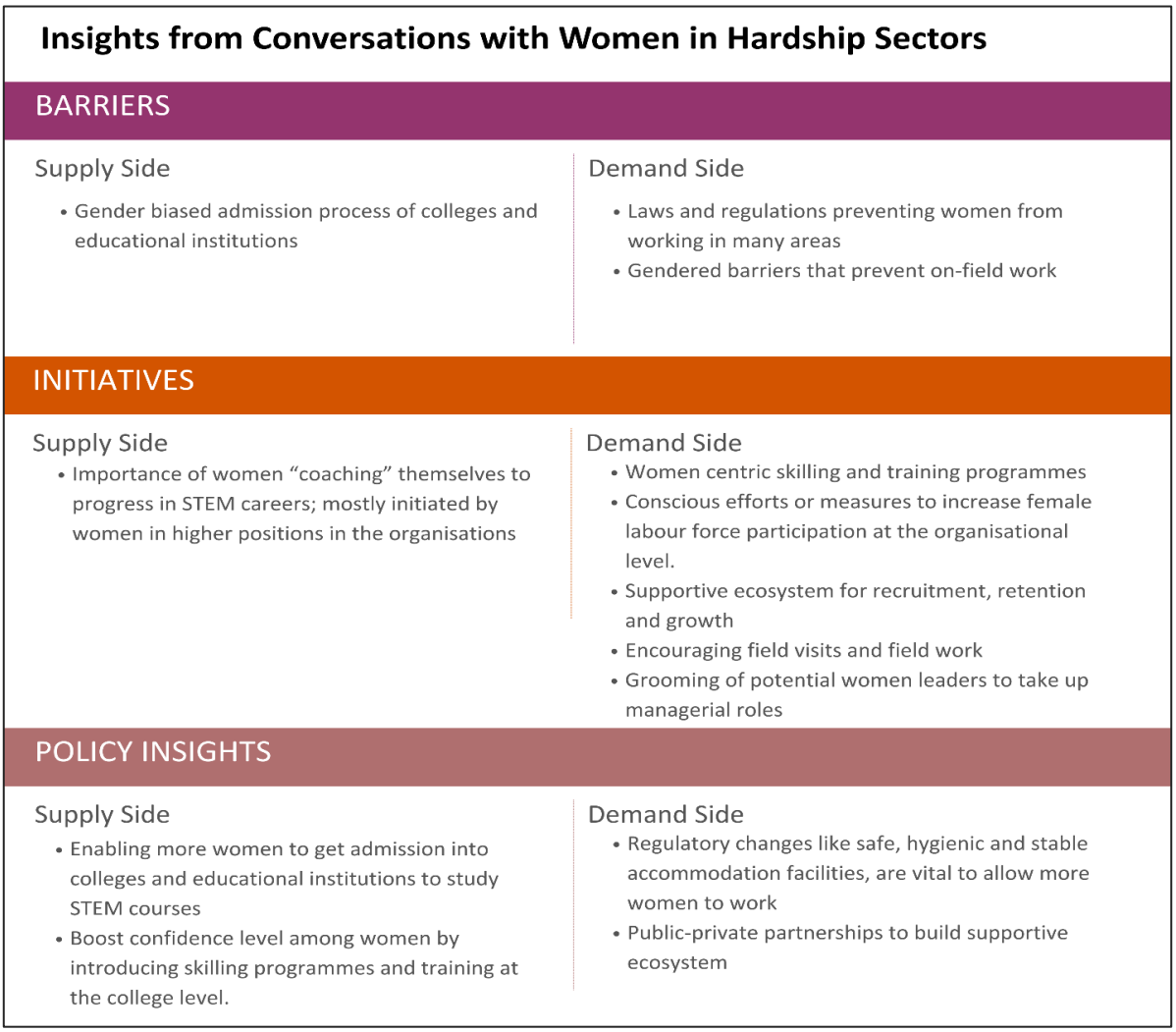
On the required policy needed to increase the proportion of women in these industries, it was pointed out that regulatory changes are vital to allow more women to work on shopfloors, factory floors, fields, manning equipment and even during night shifts. Certain initiatives and schemes by the Indian Government are already in place to enable women to take on STEM roles, and it is important to build on these schemes by adding essential changes like digital and financial literacy for the inclusion of women.

Public-Private Partnerships for Building Supportive Ecosystems

If a job is defined as hazardous, then it is equally dangerous for everyone, regardless of gender. Therefore, conducive environments are required to remove barriers like biases and discrimination. With enough examples in the workforce, women can be encouraged to enter these fields. To ensure that they contribute meaningfully, it should be ensured that the working environment also supports their induction. This can be achieved through large scale sensitisation programmes. The speed and scale of change might vary, but stronger collective voices are required to fuel the change that is desired.

"A supportive team and manager can make a real difference for women in challenging fields. I report to a male manager who allows me the flexibility to work day shifts, yet has never treated me any differently from my male counterparts."
– Interviewee

Figure 3: Highlighting the major themes that were inferred from the interviews



Source: From the Authors' interactions with the Interviewees

4 Navigating Unchartered Waters: Bridging the Gender Gap in STEM-Related Hardship Sectors

'Women in STEM' has been a topic under scrutiny in the last decade. Rapid technological advancement after the Covid-19 pandemic has also led to a surge in interest in this topic. Commensurately, governments and organisations have both begun to undertake several initiatives to tackle the numerous challenges and barriers that prevent women from entering the STEM workforce. While these policies, designed to boost the entry and retention of women in STEM fields, have had some effect, they seem to lag in making an impact on enabling women in hardcore engineering and hardship sectors. This shortfall stems from the fact that targeted incentives, such as skill programs and scholarships, disproportionately channel women toward urban, office-based tech roles rather than remote, physically demanding field work. Sector-specific cultural biases, inadequate infrastructure like safe facilities, and fewer visible female role models continue to hinder penetration in these male-dominated areas.

India's new labour reforms, introduced in 2025 (Figure 4) focus on strong protection, enhanced benefits and clearer policy representation to reform the current wage, social security and working conditions for women in India's workforce. It is expected that the effective implementation of these reforms will address several of the challenges faced by women in STEM industries today.

The reforms mandate employers to focus on providing safe, equitable and just working conditions for women to increase their participation in the workforce. Through measures like increased maternity leave, work from home accessibility, mandatory creche facilities and increased nursing breaks, the reforms aim to enable women remain in the workforce after childbirth.

Along with better social security benefits, the new codes also insist on the importance of women's representation in grievance redressal committees, ensuring their concerns are addressed fairly. Additionally, it has been mandated that one-third of all central and state advisory board members must be women, embedding women's perspectives in wage policies and employment decisions.

A significant reform has been to enable women to work in night shifts (before 6 a.m. and after 7 p.m.), with their consent and with mandatory employer-provided safety and transport arrangements.

Figure 4: New Labour Reforms 2025

Source: Ministry of Labour & Employment 2025[21]

The following section outlines reforms that can be undertaken to hire, retain and groom women in STEM careers, by highlighting best practices and schemes from both the public and private sectors. The authors also make recommendations on additional measures that can be taken to further the career prospects of women in engineering.

4.1 Addressing Gender Barriers in Stem Education

Can addressing gender norms in childhood impact women's career choices?

During early childhood, exposure to socially gendered toys and games can significantly shape children's interests and preferences in later adolescence. Boys are often encouraged to engage with automation, technology, and sports, whereas girls are steered toward activities

[21] https://static.pib.gov.in/WriteReadData/specificdocs/documents/2025/nov/doc20251127708501.pdf

such as handicrafts, painting, and teaching. These early patterns of socialisation may subsequently be reflected in the career choices of men and women. To counteract such outcomes, it is essential to ensure that children are exposed to gender-neutral toys and that technology and basic programming are introduced to all children in early education. Such measures can help offset the implicit biases that influence parental choices in toy selection. Achieving this objective will require sustained awareness campaigns to address deeply embedded societal biases and to sensitise parents to the role of gendered toys in perpetuating gender inequality.

How can the government create an ecosystem that enables women to take up STEM roles?

The Indian government has launched several schemes to encourage girls and women to join STEM fields, including engineering. Amongst these, a few like the 'New Education Policy 2020' was introduced to foster holistic and well-rounded growth of individuals with key skills of 21st century. They aim to integrate artificial intelligence and design thinking in the early schooling curriculum.

Similarly, the early introduction of courses training women with new technology used by industries can help women enter and master different types of industrial work. India's Vigyan Jyoti Programme, launched in December 2019 by the Department of Science & Technology, targets classes 9 to12 in 100 JNV schools (public residential schools). It includes mandated lab/institution visits, science camps, role-model interactions and academic support. These are limited to the JNVs and a few CBSE schools in some states. Atal Tinkering Labs (ATL), established in 10,000 schools, help inspire girls in STEM by exposing schoolchildren to different engineering fields. In 2023, the Indian Institute of Technology, Bombay (IIT-B), developed a programme in electrical engineering targeted at school girls in classes 11 and 12, which included courses on robotics, drone building, etc. Similar programmes could be conducted to give female students early exposure to career options in fields like mining, chemical, production and mechanical engineering that are perceived to be male-dominated.

Can introducing role-models in school syllabus make a difference?

Based on the conversations with the interviewees, the importance of visible role models in hardship sectors is of utmost importance. To encourage more girls to pursue careers in such fields, our education system must present engineers, geologists and miners in gender-neutral ways, especially through textbooks and curriculum design. Highlighting real life success stories can help normalise women's presence in STEM-related hardship sectors and offer young girls relatable role models. For example, the education curricula can highlight the work of Dr. G. Madhavi Latha**,** a geotechnical consultant and professor at the Indian Institute of Science (IISc), who is a key contributor to the Indian government's ambitious Chenab Bridge project – the world's highest railway arch bridge. Her role and story challenges long-held gender stereotypes in engineering and infrastructure.

Another example is Shakuntala Bhagat, the first woman civil engineer in India, who founded her own bridge-design firm and earned national recognition. She challenged the perception that large infrastructure work is unsuitable for women. Similarly, Anuradha TK made history as the first female satellite project director at ISRO. She played a key role in major satellite launches. This can inspire girls to take up careers in aerospace and space technology.

To showcase such role models on the national stage, the Government can take inspiration from the Australian **Superstars of STEM** initiative,[22] which aims to smash gendered assumptions about careers in science, technology, engineering and math. It was designed to tackle the serious gender inequity of visible role models featured in the media as experts in STEM. The programme equipped women in diverse STEM fields with advanced communication skills and opportunities – in the media, on stage and in schools. The objective was to inspire the next generations of young Australians into STEM study and careers.

Such an initiative could also be built into the Ministry of Science and Technology's Vigyan Jyoti scheme that, in addition to organising scientific camps, lectures and seminars, also focuses on interaction with role models, engaging with them in activities, laboratory visits and research fields for exposure.

4.2 From Stem Education to Workforce Participation: Fixing the Leaky Pipeline

How Can the Recent Labour Reforms 2025 be Complemented with Ecosystem Reforms?

Women's participation in STEM and hardship sectors can be scaled up if the recent labour reforms are followed up with targeted redressal of other ecosystem barriers. Within organisations, rules and model standing orders should hardwire requirements such as on-site safety committees, adequate lighting, secure facilities and clear employer duties for risk assessment and grievance redressal in STEM plants, mines and field settings.

Allowing night work without investing in public safety will not automatically to an increase in female labour supply, especially in remote industrial and mining belts. Complementary public spending on better-lit industrial areas, CCTV coverage in and around worksites, reliable police patrolling and rapid-response systems are necessary to make late-evening and night shifts meaningfully safer for women. To enable women's mobility, it will be vital to increase employer-provided or co-financed transport with GPS tracking, female security staff where feasible, and guaranteed last-mile connectivity.

[22] https://scienceandtechnologyaustralia.org.au/what-we-do/superstars-of-stem/

Can partnerships with local stakeholders and civil society help to create a more enabling ecosystem for women's field work?

The lack of supportive amenities for women to work in remote geographical locations are a significant deterrent for women. However, organisations themselves may not be able to incur the expenses of building the necessary infrastructure around their factories and project sites. Therefore, collaborations with local stakeholders are vital. Organisations can collaborate and partner with local bodies, NGOs and other stakeholders for facilities like medical setups, creches, and day-care and accommodation facilities. The government offers financial aid to states and NGOs to construct and operate accommodation for working women under the Working Women Hostels Scheme, which provide enabling facilities for women, including day-care options for children. These partnerships can provide sustainable solutions in the long run, which can cut down infrastructure and hiring costs. This could also help build a community with locals and engage with them.[23]

Can changes in organisational infrastructure and policies attract women to field work?

Based on the insights from the interviews and literature, it is evident that there are stark differences in the involvement of women in field work as compared to men. Building basic sanitation infrastructure can make a difference as the lack of basic facilities and limited access to a clean and safe environment discourage women from opting for on-site projects. On-site medical services, day-care rooms, restrooms, residential settlements and other amenities should be available to ensure a safe and healthy environment for women.

In addition to these, certain diversity, sensitivity and leadership training programmes can help men and women develop and move into leadership roles. Such training might cultivate a culture of growth and support in organisations, leading to a more inclusive workforce. Firms can take conscious steps to make their hiring processes transparent and non-discriminatory. For instance, several companies have switched to AI software to shortlist CVs of applicants. Industries like engineering and mining can use targeted promotional strategies to attract female candidates for jobs.

Can the digitalisation of processes help garner interest from girls to join engineering fields?

Automation and mechanisation in hardship sectors have great potential to make work in these sectors less laborious and, therefore, more conducive to women's participation. For instance, in mining, a recent study by Lund, E., Pekkari, A., Johansson, J. et al (2024) showed that possible transformative changes through new technology and new forms of organisation may enable organisations change the gendered structure of mining. A shift toward automated mines and a rise in industrial mining due to the demands of green transition will lead to new types of jobs and new forms of organising mining work. Within these changes lies the

[23] https://www.unesco.org/en/articles/unesco-launches-imagine-world-more-women-science-campaign#:~:text=the%20hashtag%20%23EveryVoiceInScience.-,The%

possibility of transforming gendered structures in mining. Digitalisation of processes like exploration, GIS surveying, etc., can create new opportunities that are more suitable for women in various industries.

5 Conclusion

While the global conversation around women in STEM continues to gain momentum, hardship engineering sectors such as mining, oil and gas, and heavy infrastructure remain largely absent from mainstream inclusion policies. However, this deprives organisations from benefitting from female leadership traits that contribute to the promotion and implementation of environmental and social practices – thinking systematically/holistically, managing complexity and bringing an inclusive approach to leadership (Pierli, Murmura, & Palazzi, 2022). These traits are especially critical in industries grappling with high environmental and social impacts.

Our research, based on first-hand experiences gathered from interviews, indicates that the niche and hardship engineering streams remain underexplored avenues of employment for women. These sectors offer not only economic opportunity but also the potential to redefine industrial leadership for a more sustainable and equitable future. Parents, educational institutions, and employers play key roles in shifting perceptions that field-based engineering sectors like mining and oil exploration are unsuitable for women. Recent changes in labour policies have paved the way to bring change – now targeted interventions are needed to challenge stereotypes through early exposure, inclusive practices and visible success stories.

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Appendix

Appendix A

Interviewee Profiles

Vartika Shukla, Chairperson and Managing Director, Engineers India Limited (EIL). Appointed to a leadership role on September 1, 2021, Shukla is a veteran of the organisation, having joined as a management trainee in 1988 after graduating in chemical engineering. Over a career spanning more than 34 years, she has held diverse roles and led the execution of large-scale refinery, petrochemical and fertiliser projects both in India and abroad. Her technical leadership has also driven innovation in indigenous technologies aligned with national energy security goals.

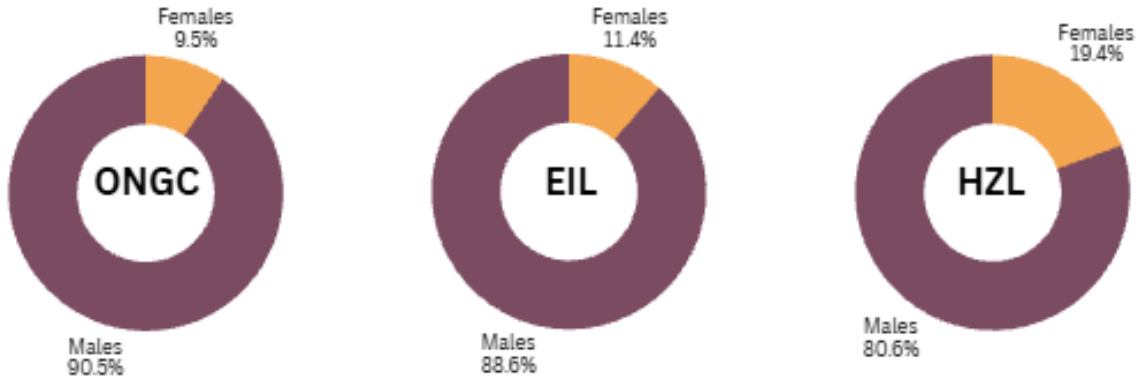
Sushma Rawat, first woman Director (Exploration) of ONGC, took the reins of the nation's top exploration position in the flagship National Oil Company – Exploration & Production (NOC E&P) Company on 1 January 2023. With over 33 years of experience, Ms. Rawat was the first woman to go on well site operations. She is a postgraduate in Geology and started her career as an operations geologist at Cauvery Basin in 1989 in ONGC. Ms. Rawat was an integral part of the Government of India's initiative to appraise the unappraised basins in the country and identify new exploration sites. She also headed the team for resource reassessment of the Mumbai Offshore Basin under "Re-assessment of Hydrocarbon Resources for Sedimentary Basins and Deep-Water Areas in India".

Sandhya Rasakatla is currently working as a health, safety, and environment (HSE) officer and as a Deputy Manager at Hindustan Zinc. She earned a degree in mining from the University College of Engineering, Kothagudem. In 2019, when the government exempted women working in mines – both above and below ground – from the restrictions of the Mines Act, 1952, she shifted from the technical team to operations. A trained rescue professional, she holds the distinction of being India's first female underground mine manager, a role she assumed at Zawarmala Mines of Hindustan Zinc.

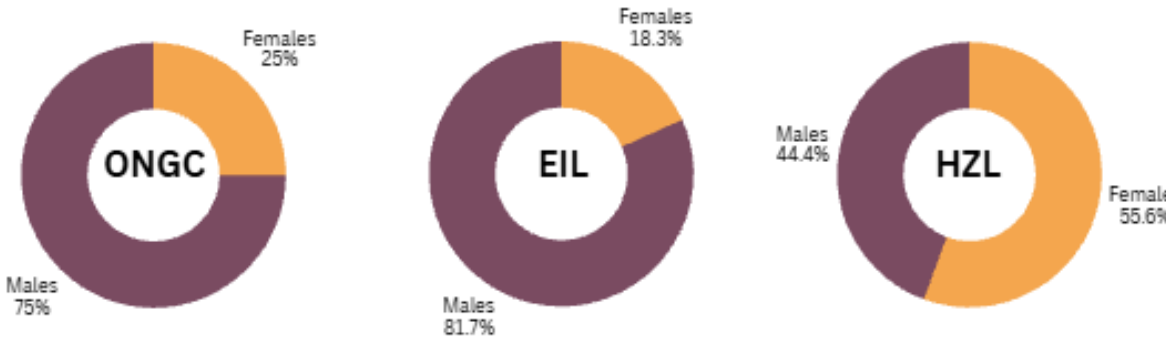
Appendix B

Figure B1: Gender breakup of the workforce and Board of Directors of organisations where interviewees are employed

a. Gender breakup of the workforce of organisations where the interviewees are employed



b. Gender breakup of the Board of Directors of organisations where the interviewees are employed



Source: Annual Reports of respective organisations (2023-24)

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