

# **Building an Inclusive Critical Mineral Economy: Adult Education as a tool for women's empowerment in India Under Expanded Brics**

**Siddhi Kumari<sup>1\*</sup>, Shiv Rani<sup>2</sup>, Pradeep<sup>3</sup>**

1 Research Scholar, Department of African Studies, University of Delhi, Delhi, India

Siddhi8506@gmail.com

2 Research Scholar, Department of Continuing Education & Extension, Faculty of Social Sciences, University of Delhi, Delhi, India

3 Research Scholar, Department of Political Science & IR, Gautam Buddha University, Greater Noida, Uttar Pradesh, India

**Abstract:** The growing global demand for critical minerals, driven by the transition to clean energy, digital technologies, and advanced manufacturing, has positioned these resources as strategic assets for sustainable economic development. India has responded by strengthening its critical mineral strategy through domestic exploration, mineral processing, recycling, and international partnerships, particularly within the expanded BRICS framework. However, the success of this transition depends on developing an inclusive and skilled workforce. This paper examines the role of adult education as a strategic tool for women's empowerment in India's emerging critical mineral economy. Drawing upon Human Capital Theory, the Capability Approach, Political Economy Theory, Feminist Political Economy, and Lifelong Learning Theory, the study adopts a qualitative, exploratory methodology based on secondary data from academic literature, government reports, and international policy documents. The analysis demonstrates that adult education enhances women's technical competencies, digital literacy, financial inclusion, entrepreneurship, and leadership, thereby improving their participation across the critical mineral value chain. The paper further highlights the significance of BRICS cooperation in promoting vocational education, technology transfer, and human capital development. It concludes that integrating adult education into India's critical mineral policies can strengthen gender-inclusive industrialisation, enhance economic resilience, and contribute to sustainable development and the achievement of the SDGs.

**Keywords:** Adult education, women's empowerment, critical minerals, India, expanded BRICS, human capital, lifelong learning, sustainable development.

## **1. INTRODUCTION**

India's pursuit of energy security, green industrialisation, and technological self-reliance has elevated critical minerals to the forefront of national policy. Minerals such as lithium, cobalt, nickel, graphite, and rare earth elements constitute the foundation of clean energy technologies, electric vehicles, battery storage systems, advanced electronics, and other strategic industries. Consequently, strengthening domestic capabilities in critical mineral exploration, processing, recycling, and international cooperation has become an essential component of India's long-

term development strategy, particularly within the framework of the expanded BRICS partnership. While policy debates have largely concentrated on resource security, supply-chain resilience, and technological advancement, the social dimension of the critical mineral transition has received comparatively limited attention. Building a competitive and sustainable mineral economy requires not only strategic resources but also an inclusive workforce capable of supporting emerging industries. Women's participation remains constrained by unequal access to technical education, vocational training, digital skills, financial resources, and leadership opportunities, particularly in rural and mineral-rich regions.

In this context, adult education emerges as a critical enabler of inclusive development. Through lifelong learning, vocational education, digital literacy, financial capability, and entrepreneurship training, adult education can equip women with the competencies required to participate effectively across the critical mineral value chain. Beyond enhancing employability, it strengthens economic agency, social inclusion, and participation in decision-making, thereby contributing to more equitable and resilient development outcomes. Against this background, this paper examines how adult education can strengthen women's participation in India's emerging critical mineral economy within the expanded BRICS framework. It argues that integrating lifelong learning and gender-responsive skill development into critical mineral policies can promote inclusive industrialisation, reinforce human capital, enhance economic resilience, and advance the Sustainable Development Goals (SDGs).

## **2. LITERATURE REVIEW**

The growing importance of critical minerals, sustainable industrialisation, and human capital development has generated increasing scholarly attention towards the role of education and women's empowerment within the BRICS economies. Existing literature indicates that adult education, digital literacy, financial inclusion, and entrepreneurship are essential for promoting gender equality and inclusive economic growth. However, limited research has specifically examined the intersection of adult education, women's empowerment, and India's critical mineral economy within the expanded BRICS framework.

Wolhuter (2023) examined education systems across BRICS countries in the post-COVID-19 context and emphasised the importance of resilient and inclusive education systems for sustainable socio-economic development. The study highlighted that digital learning, lifelong education, and skill development have become central to workforce preparedness and

economic recovery, underscoring the need for continuous learning to address emerging industrial challenges.

Isheloke (2018) explored the influence of BRICS cooperation on mineral beneficiation in South Africa and found that collaboration among BRICS countries can strengthen mineral value addition, industrial development, technology transfer, and resource governance. The study argued that effective mineral development requires investment in human capital and institutional capacity alongside mineral resource management.

Suhrab et al. (2024) examined the effect of automation and AI on economic disparity in the BRICS nations. The authors concluded that women's empowerment, education, and supportive institutional frameworks significantly reduce the adverse effects of technological transformation. The study highlighted that digital skills and inclusive education are essential for enabling women to benefit from technological advancement and future labour markets.

Floris and Goel (2024) investigated the factors influencing female entrepreneurship and women's empowerment across BRICS countries. Their findings demonstrated that education, financial inclusion, institutional support, entrepreneurial training, and policy interventions substantially improve women's business participation and contribute to poverty reduction and inclusive economic development.

Pandey and Sergeeva (2022) examined the contribution of women to economic development in BRICS countries and observed that increasing women's participation in education, employment, entrepreneurship, and leadership enhances productivity, innovation, and national economic growth. The study stressed that gender-inclusive policies are essential for achieving sustainable development across BRICS economies.

Ojo (2022) analysed the relationship between financial inclusion & women's empowerment in India and South Africa. The study found that access to financial services, education, digital technologies, and institutional support significantly enhances women's economic independence, entrepreneurial capacity, and social participation. It recommended strengthening inclusive financial and educational policies to improve women's development outcomes.

Swargiary (2025) discussed the evolving role of adult and continuing education in India, emphasising lifelong learning, vocational education, digital literacy, entrepreneurship, and

community-based capacity building. The study highlighted that adult education enhances employability, social inclusion, and workforce adaptability, making it an important instrument for women's empowerment and sustainable economic development.

Samir et al. (2026) researched the effect of computer literacy on the empowerment of women in Uttar Pradesh and found that women who get computer education had much better access to jobs, business opportunities, money, data, and decision-making authority. According to the research, women's socioeconomic empowerment in the digital economy is now dependent on their level of digital literacy.

Overall, the reviewed literature demonstrates that education, digital literacy, financial inclusion, entrepreneurship, and BRICS cooperation play significant roles in promoting women's empowerment and inclusive development. However, existing studies primarily examine these themes independently. Limited attention has been given to how adult education can support women's participation in India's critical mineral economy within the expanded BRICS framework. This study addresses this gap by integrating perspectives from critical mineral governance, adult education, women's empowerment, and BRICS cooperation to develop a comprehensive framework for inclusive and sustainable development.

### **3. THEORETICAL FRAMEWORK**

The present study adopts an interdisciplinary theoretical framework that integrates concepts from political science, development studies, gender studies, and adult education to examine the relationship between India's critical mineral strategy, expanded BRICS cooperation, adult education, and women's empowerment. Since these issues involve economic, political, social, and educational dimensions, no single theory adequately explains the phenomenon. Therefore, the study is grounded in Human Capital Theory, the Capability Approach, Political Economy Theory, Feminist Political Economy, and Lifelong Learning Theory, which collectively provide a comprehensive analytical framework.

#### **3.1 Human Capital Theory**

Human Capital Theory, established by Becker (1964) and Schultz (1961), argues that investment in education and skill development enhances individual productivity, employability, innovation, and economic growth. Later scholars such as Wuttaphan (2017) and Holden and Biddle (2017) emphasise that education remains a key driver of workforce

development and national competitiveness. In the context of India's critical mineral economy, adult education strengthens women's technical competencies, digital literacy, financial knowledge, entrepreneurial skills, and environmental awareness. These capabilities improve women's access to skilled employment in mineral exploration, processing, battery manufacturing, recycling, renewable energy industries, and related sectors. Thus, investment in women's education contributes to both individual empowerment and sustainable economic development.

### **3.2 Capability Approach**

The Capability Approach, proposed by Sen (1999) and expanded by Nussbaum (2000), views development as the expansion of individuals' capabilities and freedoms rather than merely increasing income. Education plays a central role in enhancing people's ability to make informed decisions, participate in economic activities, and improve their quality of life. Adult education enhances women's capabilities by providing technical knowledge, digital skills, financial literacy, leadership competencies, and opportunities for entrepreneurship. It also enables greater participation in environmental governance, community decision-making, and formal employment. The approach is particularly relevant for women in mineral-rich regions who often face educational, economic, and social disadvantages.

### **3.3 Political Economy Theory**

Political Economy Theory explains the interaction between political institutions, economic systems, state policies, and resource governance (Bonefeld, 2014; Cohn & Hira, 2020). It highlights how strategic natural resources influence industrial development, international relations, and national security. India's Critical Mineral Mission reflects this perspective by promoting domestic exploration, mineral processing, recycling, and international cooperation to strengthen supply-chain resilience. Within the expanded BRICS framework, political economy also emphasises South–South cooperation, technology transfer, educational exchange, and collaborative investment. Accordingly, adult education becomes an important policy instrument for developing the skilled human resources required for an inclusive and sustainable critical mineral economy.

### **3.4 Feminist Political Economy**

Feminist Political Economy examines how gender relations shape labour markets, resource governance, and economic development (Bergeron, 2001; Rao & Akram-Lodhi, 2021). It argues that women continue to face structural inequalities, with limited access to education, technical training, leadership opportunities, and productive resources. In the critical mineral sector, women remain underrepresented across exploration, mining, processing, and decision-making roles. Adult education can reduce these disparities by improving technical skills, leadership capacity, digital competence, and entrepreneurial abilities. The theory therefore supports gender-responsive policies that promote equal participation of women throughout the critical mineral value chain and strengthen inclusive economic development.

### **3.5 Lifelong Learning Theory**

Lifelong Learning Theory views education as a continuous process extending throughout an individual's life rather than being confined to formal schooling (London, 2011). Continuous learning has become increasingly important in modern economies characterised by rapid technological advancement and changing labour-market requirements. The transition towards a critical mineral economy has created demand for new competencies in battery technologies, mineral recycling, renewable energy systems, artificial intelligence, environmental management, and digital logistics. Adult education and lifelong learning programmes enable women to continuously upgrade their knowledge and skills, thereby improving their employability and adaptability. This perspective aligns with India's National Education Policy (2020), which promotes lifelong learning, digital education, and vocational skill development as essential components of inclusive national development.

### **3.6 Conceptual Framework of the Study**

Based on the above theoretical perspectives, the study proposes an integrated conceptual framework illustrating how adult education functions as a bridge between India's strategic mineral policies and women's socio-economic empowerment within the expanded BRICS context.

#### **Independent Variables**

- Adult education programmes

- Vocational training
- Digital literacy
- Technical skill development
- Financial literacy
- Entrepreneurship education
- BRICS educational cooperation

### **Mediating Variables**

- Human capital development
- Capability enhancement
- Technological competence
- Leadership development
- Institutional participation
- Digital inclusion
- Access to finance

### **Dependent Variables**

- Women's employment in critical mineral industries
- Women's entrepreneurship
- Income generation
- Leadership in mining governance
- Community participation
- Economic empowerment
- Social inclusion

- Sustainable livelihoods

### **Moderating Factors**

- Government policies
- Gender norms
- Institutional support
- Infrastructure
- Access to technology
- BRICS cooperation
- Environmental regulations

### **3.7 Relevance of the Theoretical Framework**

The integrated theoretical framework provides a comprehensive foundation for understanding how adult education can facilitate women's participation in India's emerging critical mineral economy. Investment in education and skill development, according to Human Capital Theory, boosts productivity, employability, and economic growth (Becker, 1964; Schultz, 1961; Wuttaphan, 2017). The Capability Approach emphasises that education expands women's capabilities, agency, and opportunities for meaningful participation in economic and social life (Sen, 1999; Nussbaum, 2000). Political Economy Theory situates critical minerals within the broader context of industrial policy, state strategy, and international cooperation, highlighting the importance of skilled human resources for sustainable resource governance (Bonefeld, 2014; Cohn & Hira, 2020). Feminist Political Economy underscores the structural barriers that restrict women's access to education, employment, and leadership while advocating gender-responsive policies for equitable participation (Bergeron, 2001; Rao & Akram-Lodhi, 2021). Finally, Lifelong Learning Theory stresses the need for continuous reskilling and upskilling to meet the technological demands of the evolving critical mineral sector (London, 2011).

Collectively, these theoretical perspectives demonstrate that women's inclusion in India's critical mineral economy depends not only on the availability of strategic mineral resources but also on sustained investments in adult education, institutional capacity building, and



inclusive governance. The framework therefore supports the central proposition of this study that adult education is a strategic policy instrument that strengthens human capital, expands women's capabilities, promotes gender-inclusive participation in the critical mineral value chain, and contributes to sustainable economic development within the expanded BRICS framework. This integrated perspective forms the conceptual basis for analysing the role of adult education in building an inclusive and resilient critical mineral economy in India.

#### **4. OBJECTIVES OF THE STUDY**

1. To examine the political and economic significance of the critical mineral economy within the expanded BRICS framework.
2. To analyse the role of adult education in enhancing women's participation in India's critical mineral value chains.
3. To identify institutional and socio-economic barriers limiting women's inclusion in the mineral economy.
4. To propose policy recommendations for integrating adult education into India's critical mineral governance strategy.

#### **5. RESEARCH METHODOLOGY**

##### **5.1 Research Design**

This study adopts a qualitative descriptive and analytical research design to study the role of adult education in promoting women's empowerment within India's emerging critical mineral economy under the expanded BRICS framework. Given the policy-oriented nature of the study, the research focuses on analysing government initiatives, institutional frameworks, international cooperation, and scholarly literature rather than collecting primary data. The interdisciplinary approach integrates perspectives from political science, gender studies, development studies, and adult education to understand the relationship between resource governance and inclusive development.

##### **5.2 Nature of the Study**

The investigation is descriptive, analytical, & exploratory. It describes India's critical mineral strategy and the evolving role of expanded BRICS, analyses the contribution of adult education

to women's economic empowerment, and explores policy mechanisms for promoting gender-inclusive participation in the critical mineral value chain.

### **5.3 Sources of Data**

Secondary data derived from credible and reputable sources forms the basis of the study. These include:

- Government of India publications (Ministry of Mines, Ministry of Education, Ministry of Women and Child Development, NITI Aayog, Geological Survey of India, National Skill Development Corporation)
- BRICS Summit Declarations and BRICS policy reports
- Publications of international organisations such as UNESCO, UN Women, World Bank, IEA, ILO, and OECD
- Peer-reviewed journal articles indexed in Scopus and Web of Science
- Books, policy papers, conference proceedings, & reports related to critical minerals, adult education, women's empowerment, and sustainable development.

### **5.4 Method of Data Analysis**

The data were evaluated through the use of thematic and qualitative content analysis. Relevant documents were systematically reviewed and organised into key themes, including critical mineral governance, BRICS cooperation, adult education, women's empowerment, skill development, and sustainable development. The analysis focused on identifying patterns, policy priorities, institutional initiatives, and emerging opportunities for enhancing women's participation in the critical mineral economy. Comparative analysis of national and international policy frameworks was also undertaken to formulate an integrated policy perspective.

### **5.5 Analytical Framework**

The study examines the interrelationship among four core dimensions:

- **Critical Mineral Economy:** resource governance, mineral value chains, industrial policy, and strategic security.

- **Adult Education:** lifelong learning, vocational education, digital literacy, technical skills, and entrepreneurship.
- **Women's Empowerment:** employment, economic participation, leadership, financial inclusion, and decision-making.
- **Expanded BRICS:** international cooperation, technology transfer, knowledge sharing, and sustainable development.

These dimensions are analysed within the broader framework of political economy and inclusive governance to understand how adult education can facilitate women's integration into India's critical mineral ecosystem.

### **5.6 Ethical Considerations**

The research is based exclusively on secondary sources; therefore, no human participants were involved, and no ethical clearance or informed consent was required. All information has been obtained from publicly available and credible sources, with due acknowledgement through appropriate academic citation and referencing.

### **5.7 Scope and Limitations**

The study focuses on India's critical mineral strategy, the role of expanded BRICS, and the potential of adult education to enhance women's participation in the critical mineral economy. It is limited to secondary data and policy analysis and does not include primary surveys or empirical case studies. Since policies relating to critical minerals and BRICS cooperation continue to evolve, future developments may influence some of the study's observations and recommendations.

## **6. INDIA'S CRITICAL MINERAL STRATEGY AND EXPANDED BRICS: OPPORTUNITIES FOR INCLUSIVE DEVELOPMENT**

The strategic importance of essential minerals including lithium, cobalt, nickel, graphite, and rare earth elements has grown substantially due to the worldwide shift towards clean energy, digital technology, and sustainable industrialisation. Central to economic competitiveness and energy security are these minerals, which are necessary for electric vehicles, renewable energy technologies, semiconductors, and sophisticated manufacturing (Rao et al., 2024; Yaseen et

al., 2025). Consequently, countries are strengthening critical mineral supply chains through strategic policies, international partnerships, and domestic industrial development.

For India, critical minerals have become a strategic priority for achieving energy transition goals, technological self-reliance, and sustainable economic growth. Simultaneously, the expansion of BRICS has created new opportunities for resource cooperation, technology transfer, investment, and resilient supply chains among emerging economies (Iqbal & Rahman, 2023; Müller, 2025). Integrating adult education and women's empowerment into this strategy can enhance human capital, promote inclusive participation, and ensure that the benefits of the critical mineral economy contribute to equitable and sustainable development.

### **6.1 India's Critical Mineral Strategy**

India has recognised that heavy dependence on imported critical minerals poses risks to industrial growth, clean energy transition, and national security. In response, the Government of India has prioritised domestic exploration, mineral processing, recycling, technological innovation, and international partnerships to strengthen critical mineral security (Jayaram & Ramu, 2024; Godbole et al., 2026). Earlier studies also highlighted the importance of securing non-fuel critical minerals to support India's manufacturing and strategic sectors (Gupta et al., 2016). The country's strategy focuses on expanding mineral exploration, strengthening domestic processing capabilities, promoting circular economy practices, encouraging research and innovation, diversifying international supply sources, and developing a skilled workforce. These initiatives reflect India's transition from treating minerals as conventional natural resources to recognising them as strategic assets essential for long-term economic resilience and industrial competitiveness (Jayaram & Ramu, 2024; Godbole et al., 2026).

### **6.2 Expanded BRICS and Critical Mineral Cooperation**

The expansion of BRICS has strengthened cooperation among resource-rich and rapidly industrialising economies, enhancing opportunities for critical mineral security and sustainable development. BRICS countries possess significant mineral reserves, manufacturing capabilities, financial resources, and technological expertise, enabling collaborative approaches to mineral governance and supply-chain resilience (Dergachev, 2021; Rubina, 2024). For India, BRICS cooperation offers opportunities to diversify mineral supply chains, promote technology transfer, strengthen South–South cooperation, expand

collaborative research, and attract investment in mineral processing and clean-energy industries (Müller, 2025). The expansion of BRICS also broadens cooperation in education, innovation, digital transformation, and capacity building, creating favourable conditions for integrating human capital development into critical mineral policies (Kazelko & Semeghini, 2024; Iqbal & Rahman, 2023).

### **6.3 Inclusive Development in the Critical Mineral Economy**

Inclusive development requires that the benefits of the critical mineral economy are equitably distributed among governments, industries, local communities, women, and marginalised populations. Sustainable mineral development should generate employment, strengthen local livelihoods, promote gender equality, and ensure environmental responsibility (Heffron, 2020; Brown et al., 2024).

Mining regions frequently experience socio-economic inequalities despite their resource wealth. Therefore, inclusive mineral governance should emphasise community participation, skill development, social protection, environmental sustainability, and equitable benefit-sharing. Such an approach contributes to both economic growth and social justice while supporting India's sustainable development objectives (Bird, 2016; Brown et al., 2024).

### **6.4 Women's Participation in the Critical Mineral Value Chain**

Women remain underrepresented across mining and mineral industries due to gender stereotypes, limited technical training, occupational segregation, and institutional barriers (Makaza & Chimuzinga, 2020). However, technological advancements and automation have expanded opportunities for women beyond traditional mining activities.

Women can increasingly participate in geological exploration, laboratory analysis, mineral processing, battery manufacturing, environmental monitoring, logistics, recycling, research, and regulatory institutions. Enhancing women's technical skills and educational opportunities can improve their participation across the critical mineral value chain while contributing to gender equality and sustainable industrial development (Hilson, 2025).

### **6.5 Adult Education as a Strategic Enabler**

Adult education is a key driver of workforce development in the critical mineral sector. Modern adult education extends beyond literacy to include vocational training, digital literacy,

financial literacy, entrepreneurship, technical education, and lifelong learning (Boyadjieva & Ilieva-Trichkova, 2023).

For women, adult education strengthens technical competence, digital skills, financial inclusion, leadership, and entrepreneurial capacity, thereby improving access to skilled employment and enterprise development. Flexible learning systems, community-based training, digital platforms, and industry partnerships further enhance women's participation in emerging mineral industries (Verma & Ambedkar, 2023). Integrating adult education into India's critical mineral strategy can therefore promote inclusive workforce development and sustainable economic growth.

### **6.6 Policy Initiatives Supporting Women's Empowerment**

India has introduced several initiatives that indirectly support women's participation in emerging industrial sectors, including the NEP (2020), Skill India Mission, National Skill Development Mission, Digital India, Stand-Up India, Startup India, NRLM, and PMKVY. These programmes promote lifelong learning, vocational education, entrepreneurship, digital inclusion, and skill development. Aligning these initiatives with the critical mineral sector can create specialised training pathways for women in mineral exploration, battery manufacturing, recycling, environmental management, and renewable energy industries.

### **6.7 Challenges to Inclusive Critical Mineral Development**

Despite significant policy progress, several challenges continue to impede women's participation in India's critical mineral economy.

- Many women, particularly in rural and tribal regions, lack access to technical education and specialised vocational training.
- Unequal access to digital infrastructure limits participation in technology-driven industries and online learning platforms.
- Persistent social norms often discourage women from pursuing careers in mining, engineering, and industrial occupations.
- Inadequate childcare facilities, workplace safety measures, mentoring programmes, and career advancement opportunities reduce women's workforce participation.

- Limited access to credit, investment, and entrepreneurial support restricts women's ability to establish enterprises within mineral value chains.
- Mineral-rich regions frequently experience deficiencies in educational institutions, healthcare, transportation, and digital connectivity.

Addressing these barriers requires coordinated policy interventions involving government agencies, educational institutions, industry, civil society, and local communities.

### **6.8 Role of BRICS in Promoting Inclusive Human Capital Development**

Expanded BRICS provides a valuable platform for strengthening human capital through collaborative education and skill development initiatives. Member countries can cooperate in:

- Vocational education programmes;
- Technical training exchanges;
- Digital learning platforms;
- Research collaboration;
- Women's entrepreneurship networks;
- Sustainable mining practices;
- Environmental governance;
- Innovation and technology transfer.

Such cooperation can facilitate knowledge sharing, improve workforce mobility, and strengthen institutional capacities across member countries. Joint educational initiatives focused on critical minerals can prepare women for emerging employment opportunities while supporting sustainable industrial development.

## **7. ADULT EDUCATION AND WOMEN'S EMPOWERMENT IN INDIA'S CRITICAL MINERAL ECONOMY**

The transition towards a critical mineral economy has created significant opportunities for employment, innovation, and industrial growth. However, realising these opportunities requires a skilled and inclusive workforce. Adult education plays a critical role in equipping

women with technical knowledge, digital literacy, vocational skills, and entrepreneurial capabilities needed for participation in emerging industries (Swargiary & Roy, 2023). Lahiri-Dutt (2007) notes that gender-based occupational restrictions, educational disparities, and socio-economic inequality have all contributed to the historically low levels of female engagement in India's extractive fields, including mining. Integrating adult education into India's critical mineral strategy can therefore strengthen women's socio-economic empowerment while promoting inclusive and sustainable industrial development.

### **7.1 Adult Education as a Tool for Women's Empowerment**

Adult education extends beyond basic literacy to include lifelong learning, vocational education, digital literacy, financial education, and entrepreneurship development. These learning opportunities enhance women's employability, confidence, decision-making capacity, and economic independence (Swargiary & Roy, 2023). Dashottar (2025) argues that education is a key determinant of gender equality, enabling women to access better employment opportunities, participate in leadership roles, and improve their socio-economic status. Within the critical mineral economy, adult education strengthens women's technical competencies, financial literacy, entrepreneurial skills, and awareness of occupational safety and environmental sustainability. These capabilities improve women's participation in formal employment, self-employment, and community governance, thereby contributing to inclusive economic development (Dashottar, 2025).

### **7.2 Skill Development for the Critical Mineral Sector**

The critical mineral industry requires skilled professionals across exploration, mineral processing, battery manufacturing, recycling, environmental management, and digital technologies. Adult education and vocational training provide women with industry-relevant competencies that improve employability in these emerging sectors (Swargiary & Roy, 2023). Skill development programmes focusing on geological surveying, laboratory analysis, mineral processing, renewable energy technologies, Geographic Information Systems (GIS), environmental monitoring, logistics, and regulatory services can significantly expand women's participation in the critical mineral value chain. Industry-led training, apprenticeships, and certification programmes are therefore essential for creating a gender-inclusive skilled workforce.



### **7.3 Digital Literacy and Technological Inclusion**

Rapid technological advancements have transformed mineral exploration, mining operations, and supply-chain management through automation, artificial intelligence, remote sensing, and digital monitoring systems. Consequently, digital literacy has become an essential component of adult education (Swargiary & Roy, 2023). Women equipped with digital competencies are better positioned to access online training, operate digital technologies, utilise e-commerce platforms, manage digital financial services, and participate in technology-driven occupations. Expanding digital infrastructure and digital education, particularly in rural and mineral-rich regions, is therefore crucial for promoting equitable participation in the critical mineral economy.

### **7.4 Entrepreneurship and Economic Participation**

Adult education promotes women's entrepreneurship by strengthening business management, financial planning, marketing, and enterprise development skills. Increased educational attainment has also been associated with greater female labour force participation and improved economic opportunities (Lahoti & Swaminathan, 2016). Within the critical mineral economy, entrepreneurial opportunities exist in mineral recycling, battery collection, laboratory services, environmental consultancy, logistics, renewable energy maintenance, and vocational training. In addition to empowering women economically, these businesses help the local economy grow, provide jobs, and generate cash (Dashottar, 2025).

### **7.5 Adult Education and Sustainable Mining Practices**

Sustainable mining requires environmentally responsible resource management, occupational safety, community participation, and social accountability. Adult education promotes awareness of environmental conservation, waste management, biodiversity protection, climate change mitigation, and responsible mining practices (Swargiary & Roy, 2023). Women who receive education & technical training are better equipped to participate in environmental monitoring, local governance, and community decision-making, thereby strengthening sustainable mineral governance. Gender-sensitive approaches to mining also improve community well-being and contribute to more inclusive development outcomes (Lahiri-Dutt, 2007).

### **7.6 Role of Community Learning and Local Institutions**

Community learning institutions play an important role in extending educational opportunities to women in rural and mining regions. Panchayati Raj Institutions, Self-Help Groups (SHGs), Industrial Training Institutes (ITIs), Jan Shikshan Sansthan (JSS), community colleges, and non-governmental organisations can provide vocational training, digital literacy, financial education, entrepreneurship development, environmental awareness, and leadership training (Swargiary & Roy, 2023). Localised learning models improve accessibility and enable women to acquire industry-relevant skills while balancing household and community responsibilities, thereby enhancing their participation in the critical mineral economy.

### **7.7 Government Initiatives Supporting Adult Education**

The Government of India has introduced several initiatives to strengthen adult education, vocational training, and workforce development, including the New India Literacy Programme (ULLAS), NEP (2020), Skill India Mission, PMKVY, Digital India Mission, and the NSDC. These programmes promote lifelong learning, digital inclusion, technical education, and entrepreneurship. Aligning these initiatives with India's critical mineral strategy can facilitate specialised training in mining technologies, mineral processing, battery manufacturing, recycling, renewable energy, and environmental management, thereby expanding women's employment opportunities and industrial participation (Dashottar, 2025).

### **7.8 BRICS Cooperation in Adult Education and Capacity Building**

Expanded BRICS provides opportunities for strengthening human capital through collaborative education, vocational training, research partnerships, technology transfer, and digital learning. Cooperation among BRICS countries can facilitate joint skill development programmes, faculty exchange, women's entrepreneurship initiatives, and sustainable mining research. Integrating adult education with BRICS cooperation can improve workforce competencies, strengthen institutional capacity, promote knowledge sharing, and enhance women's participation in the critical mineral economy. Such collaboration supports inclusive industrialisation while contributing to sustainable economic development and gender equality (Swargiary & Roy, 2023; Dashottar, 2025).

## **8. DISCUSSION AND POLICY IMPLICATIONS**

### **8.1 Discussion**

This study's results show that a trained, inclusive, and gender-responsive workforce is just as important as safe access to crucial minerals for India's critical mining industry to grow. Investing in human capital is now just as vital as investing in natural resources, because the clean energy transition and digital transformation are driving up the global demand for critical minerals (Rao et al., 2024; Godbole et al., 2026). To better equip women to take part in the growing essential mineral value chain, adult education becomes an important strategic tool in this setting.

There is theoretical backing for this connection. Education, according to Human Capital Theory (Becker, 1964; Schultz, 1961), increases output, employability, and GDP growth. Similarly, the Capability Approach emphasises that education expands women's capabilities, agency, and opportunities for meaningful participation in economic and social life (Sen, 1999; Nussbaum, 2000). These perspectives indicate that adult education can strengthen women's technical competencies, digital literacy, financial knowledge, and entrepreneurial capacity, thereby improving their participation in mineral exploration, processing, battery manufacturing, recycling, renewable energy, and related industries.

The study also highlights that women's participation in India's mining and extractive industries continues to be constrained by structural barriers, including limited access to technical education, occupational segregation, gender stereotypes, inadequate institutional support, and digital inequalities (Lahiri-Dutt, 2007; Lahoti & Swaminathan, 2016). Adult education can address many of these challenges by providing flexible learning opportunities, vocational training, and lifelong skill development that enhance employability and leadership. Furthermore, education contributes to women's health, well-being, and decision-making capacity, strengthening their overall socio-economic empowerment (D'Souza et al., 2013; Dashottar, 2025).

The expansion of BRICS further strengthens the prospects for inclusive development by facilitating cooperation in critical mineral governance, technology transfer, vocational education, research collaboration, and human capital development (Müller, 2025; Iqbal & Rahman, 2023). Such collaboration can enable India to develop a skilled workforce while

promoting South–South cooperation in sustainable mining, innovation, and gender-inclusive industrialisation.

## **8.2 Policy Implications**

These policy recommendations are based on the results:

- Adult education should be integrated into India's critical mineral strategy to develop a skilled and gender-inclusive workforce capable of supporting emerging mineral industries.
- Specialised vocational training programmes should be introduced in collaboration with universities, Industrial Training Institutes (ITIs), industry, and the National Skill Development Corporation to prepare women for employment in mineral exploration, processing, battery manufacturing, recycling, renewable energy, and environmental management.
- Government initiatives such as the National Education Policy (2020), Skill India Mission, Digital India, PMKVY, and ULLAS should incorporate specialised modules on critical minerals, digital technologies, and green skills to enhance women's employability.
- Greater investment is needed to improve digital infrastructure, technical education, and community-based learning centres in rural and mineral-rich regions to reduce educational and digital disparities.
- Financial support, entrepreneurship training, incubation programmes, and easier access to credit should be provided to encourage women-led enterprises in mineral recycling, battery technologies, environmental services, and circular economy businesses.
- Gender-responsive labour policies should ensure equal employment opportunities, safe working conditions, leadership development, mentoring, childcare facilities, and career progression for women in the mining and critical mineral sectors.
- BRICS member countries should strengthen cooperation in vocational education, technology transfer, research collaboration, digital learning platforms, and women-

focused entrepreneurship programmes to enhance human capital development and knowledge sharing (Müller, 2025).

- Sustainable mining policies should promote community participation, environmental awareness, occupational safety, and social accountability through adult education and continuous capacity-building programmes.

## 9. CONCLUSION

The transition towards a critical mineral economy presents India with a unique opportunity to achieve sustainable industrial growth, energy security, and technological advancement. However, the success of this transition depends not only on the availability of strategic mineral resources but also on the development of an inclusive and skilled workforce. This paper argues that adult education is a strategic enabler of women's empowerment by enhancing technical skills, digital literacy, financial capability, entrepreneurship, and leadership, thereby facilitating women's participation across the critical mineral value chain. The integration of adult education with India's critical mineral strategy can strengthen human capital, reduce gender disparities, and promote equitable access to emerging employment and entrepreneurial opportunities. Furthermore, the expanded BRICS framework offers significant potential for cooperation in vocational education, technology transfer, research, and capacity building, supporting inclusive human resource development. By aligning educational initiatives with critical mineral policies, India can foster a gender-responsive and sustainable mineral economy. Ultimately, investing in adult education and women's empowerment will contribute to resilient supply chains, inclusive economic growth, and the achievement of national development priorities and the Sustainable Development Goals.

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