Gender, Adult Education And Sustainable Development: Linking Women's Empowerment With India's Critical Mineral Strategy

Siddhi Kumari[1*], Shiv Rani[2], Pradeep[3]

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 global transition towards clean energy has increased the strategic importance of critical minerals, making their governance a key policy priority for India. This paper examines the interrelationship between gender, adult education, and sustainable development in the context of India's critical mineral strategy from a political science perspective. Using a qualitative approach based on policy documents, government reports, and recent scholarly literature, the study analyses how adult education and women's empowerment can strengthen inclusive and sustainable mineral governance. The paper argues that gender-responsive policies, lifelong learning, and participatory governance enhance women's access to education, green skills, employment, leadership, and decision-making across the critical mineral value chain. It further proposes an integrated governance framework linking resource security with environmental sustainability, community participation, and human capital development. The findings suggest that embedding adult education and gender equality into India's critical mineral policies can improve governance effectiveness, promote social justice, support the green economy, and contribute to achieving the Sustainable Development Goals (SDGs).

Keywords: Critical Minerals; Gender Equality; Adult Education; Women's Empowerment; Sustainable Development; Critical Mineral Governance; Political Economy

1. INTRODUCTION

India's transition towards a green economy has placed critical mineral governance at the centre of sustainable development policy. Beyond ensuring the availability of strategic minerals, effective governance requires transparent institutions, environmental stewardship, equitable benefit-sharing, and meaningful community participation. As mineral extraction increasingly intersects with climate action and industrial transformation, governance frameworks must

balance economic growth with social justice and long-term sustainability. Women remain largely excluded from governance processes in mineral-bearing regions because of unequal access to education, technical knowledge, and decision-making opportunities. Their limited participation weakens the inclusiveness of mineral policies and reduces the potential for community-led resource management. Adult education and lifelong learning can address these challenges by strengthening legal awareness, environmental literacy, leadership, and civic participation, thereby enabling women to engage more effectively in local governance and sustainable mineral development.

While existing research primarily focuses on critical mineral security, supply chains, and industrial policy, comparatively little attention has been given to the governance dimensions of women's empowerment and adult education. Addressing this gap, this paper examines how gender-responsive governance and lifelong learning can strengthen sustainable critical mineral management in India. It proposes an integrated framework linking adult education, women's participation, and participatory governance to support responsible mineral development and the achievement of the Sustainable Development Goals (SDGs).

2. CRITICAL MINERAL GOVERNANCE IN INDIA

Critical minerals have emerged as one of the most significant strategic resources of the twenty-first century because of their indispensable role in renewable energy technologies, electric mobility, digital infrastructure, defence systems, and advanced manufacturing. Unlike conventional minerals, critical minerals are characterised by high economic importance and significant risks associated with supply concentration, geopolitical instability, limited substitutes, and growing global demand. The accelerating transition towards low-carbon energy systems has transformed these minerals into strategic assets, compelling countries to formulate comprehensive policies that ensure long-term resource security while maintaining environmental sustainability and social inclusion.

Crucial minerals have taken center stage in Indian national policy due to the country's ambitious goals of reaching zero emissions by 2070, increasing renewable energy capacity to 500 GW of non-fossil power generation, bolstering domestic manufacturing, and promoting electric mobility. According to Godbole et al. (2026) and Mishra (2025), the Indian government has taken various steps to strengthen its supply chains, such as establishing the National Critical Mineral Mission, revising the Mines and Minerals (Development and

Regulation) Act, forming international mineral partnerships, and making strategic acquisitions abroad. The governance of critical minerals extends beyond resource extraction and industrial development. Contemporary governance frameworks increasingly recognise that responsible mineral development requires balancing economic competitiveness with environmental sustainability, social justice, gender equality, community participation, and transparent institutional arrangements. This multidimensional perspective aligns closely with the SDGs, particularly SDGs 4, 5, 8, 9, 12, 13, and 16.

2.1 Understanding Critical Minerals

Critical minerals are distinct as minerals that possess high economic and strategic importance while facing elevated risks of supply disruption due to geological scarcity, geopolitical concentration, limited substitutability, or technological dependence. Although different countries maintain different lists of critical minerals, most classification systems evaluate minerals according to three principal criteria:

- Economic importance;
- Strategic industrial applications; and
- Supply vulnerability.

These criteria are reflected in the policy frameworks of India, the EU, the US, Australia, Japan, and the IEA. The minerals most commonly identified as critical include lithium, cobalt, nickel, graphite, copper, rare earth elements, manganese, and vanadium, which constitute essential raw materials for batteries, electric vehicles, wind turbines, solar photovoltaic systems, semiconductors, defence equipment, and digital technologies (Singh, 2025). According to the IEA, renewable energy technologies require substantially larger quantities of minerals than conventional fossil-fuel systems. The mineral inputs needed for electric vehicles are many times more than those for internal combustion vehicles. Meanwhile, the infrastructure for wind and solar energy relies substantially on copper, lithium, nickel, cobalt, and rare earth elements. That is why these minerals are going to be in high demand during the next few decades all across the world.

Table 1. Major Critical Minerals and Their Strategic Applications

Critical Mineral	Major Applications	Strategic Importance
Lithium	EV batteries, energy storage	Clean energy transition
Cobalt	Lithium-ion batteries	Battery stability
Nickel	EV batteries, stainless steel	High-energy batteries
Copper	Transmission, EV motors	Electrification
Graphite	Battery anodes	Energy storage
Rare Earth Elements	Wind turbines, electronics, defence	High-tech manufacturing
Manganese	Battery chemistry	Renewable energy
Vanadium	Grid-scale storage	Energy security

Source: Adapted from Chadha et al. (2021); Godbole et al. (2026).

2.2 Global Governance of Critical Minerals

The global political economy of critical minerals is characterised by rapidly increasing demand combined with geographically concentrated production and processing. Although mineral reserves are distributed across several countries, refining and processing capacities remain concentrated in a limited number of economies, creating significant geopolitical dependencies. The uploaded reference "The Political Economy of Critical Minerals" demonstrates that China dominates global refining of graphite, cobalt, lithium and rare earth elements, while countries such as the Democratic Republic of Congo, Indonesia, Chile and Australia control substantial shares of upstream production. This asymmetry has transformed critical minerals into instruments of geopolitical influence and strategic competition.

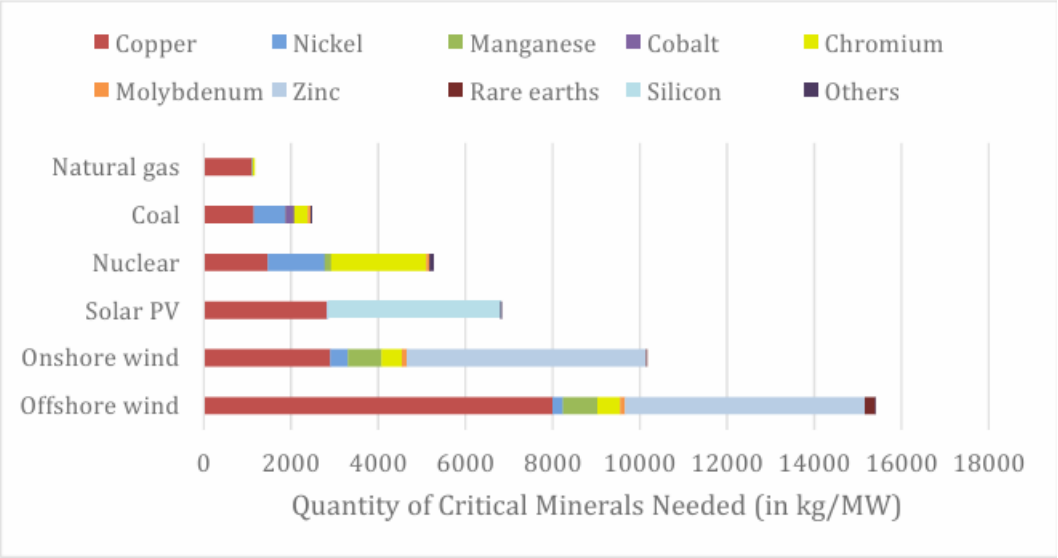

Figure 1. Global Distribution of Critical Mineral Production.

Source: Adapted from International Energy Agency (2024) as reproduced in Singh (2025).

2.3 India's Emerging Critical Mineral Strategy

India's critical mineral strategy has evolved rapidly during the last five years in response to increasing energy security concerns, technological competition, and geopolitical uncertainty. According to Godbole et al. (2026), India has shifted from being largely dependent on imported strategic minerals towards developing an integrated policy framework encompassing mineral exploration, overseas acquisitions, domestic processing, recycling, and international cooperation.

The strategy rests upon five major pillars:

1. Domestic exploration and geological mapping;
2. Overseas mineral asset acquisition;
3. Supply chain diversification;
4. Circular economy and mineral recycling;
5. Strategic international partnerships.

India has identified more than thirty critical minerals essential for national development. Several of these minerals are located within states such as Rajasthan, Odisha, Karnataka,

Jharkhand, Andhra Pradesh, and Chhattisgarh, highlighting the importance of integrating state governments and local communities into mineral governance (Godbole et al., 2026). Mishra (2025) argues that India's energy transition depends upon secure access to lithium, cobalt, graphite, nickel, and rare earth elements for manufacturing electric vehicles, battery storage systems, renewable energy technologies, and advanced electronics. Consequently, critical mineral governance has become closely linked with industrial policy, climate policy, and national security.

2.4 Governance Challenges

Despite recent policy reforms, India continues to face several governance challenges in securing critical mineral supply chains. High dependence on imports of lithium, cobalt, and rare earth elements exposes the country to global market volatility, geopolitical tensions, and supply disruptions. Mining activities also pose significant environmental challenges, including land degradation, water pollution, biodiversity loss, greenhouse gas emissions, and waste generation, necessitating stronger environmental regulations and monitoring mechanisms. Additionally, many critical mineral deposits are located in tribal and forest regions, creating challenges in balancing national resource security with indigenous rights, environmental justice, and community participation. Effective governance is further constrained by the need for better coordination among multiple ministries, state governments, and regulatory agencies involved in mineral development. Strengthening institutional coordination, promoting responsible mining practices, accelerating domestic exploration, and enhancing regulatory capacity are therefore essential for ensuring a secure, sustainable, and inclusive critical mineral governance framework in India (Singh, 2026).

2.5 Governance and Sustainable Development

Modern critical mineral governance increasingly adopts Environmental, Social and Governance (ESG) principles. The recently uploaded report "The Criticality of Gender Equality in the Race for Critical Minerals" argues that mineral governance should extend beyond economic efficiency to incorporate human rights, gender equality, environmental integrity, transparency and equitable benefit sharing. The report highlights seven guiding principles promoted by the United Nations Panel on Critical Energy Transition Minerals, including:

- Human rights protection;
- Environmental integrity;
- Equitable benefit sharing;
- Transparency and accountability;
- Responsible finance;
- International cooperation;
- Inclusive governance.

These principles closely correspond with India's constitutional commitment to social justice and sustainable development.

2.6 Adult Education and Community Governance

An important but underexplored dimension of India's critical mineral strategy concerns human capital development. Successful mineral governance depends not only upon technological innovation but also upon educated and informed communities capable of participating effectively in environmental management, local planning and public consultation.

Adult education contributes to governance by:

- increasing environmental literacy;
- strengthening awareness of legal rights;
- improving technical and vocational skills;
- promoting financial inclusion;
- enhancing women's participation in Panchayati Raj Institutions;
- supporting community monitoring of mining activities.

These capabilities are particularly important in mineral-bearing districts where local populations interact directly with mining projects and environmental change.

2.7 Critical Mineral Governance and Inclusive Development

From a political science perspective, India's critical mineral strategy represents more than an industrial policy initiative; it is a governance framework linking economic development, environmental sustainability, democratic participation and social inclusion. Integrating gender-responsive policies, adult education and community engagement can enhance the legitimacy and effectiveness of mineral governance while reducing social conflicts and promoting equitable distribution of development benefits. Recent policy discussions increasingly recognise that the success of India's green transition depends not only on securing mineral supplies but also on ensuring that mining contributes to inclusive development, environmental stewardship and local empowerment. Consequently, governance models must evolve from resource extraction towards participatory and sustainable management of critical mineral resources.

3. GENDERED POLITICAL ECONOMY OF CRITICAL MINERALS

The rapid global transition towards renewable energy and digital technologies has transformed critical minerals into strategic resources central to economic development, energy security, and geopolitical competition. While discussions on critical minerals often focus on resource availability, supply-chain resilience, technological innovation, and international trade, comparatively little attention has been devoted to their gendered political economy. The extraction, processing, and governance of critical minerals are embedded within social structures characterised by unequal access to resources, employment, education, political participation, and decision-making. Consequently, women experience both the opportunities and the costs of the green transition differently from men. The concept of the gendered political economy of critical minerals examines how gender relations influence access to mineral resources, employment opportunities, technological capabilities, governance institutions, and the distribution of economic benefits. It recognises that resource governance is not gender neutral but shaped by existing inequalities related to education, land ownership, labour markets, financial inclusion, and political representation. Integrating gender perspectives into India's critical mineral strategy is therefore essential for ensuring that the benefits of mineral-led development contribute to sustainable and inclusive growth rather than reinforcing existing social disparities.

3.1 Political Economy Perspective on Critical Minerals

Political economy examines the interaction between political institutions, economic systems, and societal power relations. Within the context of critical minerals, political economy focuses on how governments, multinational corporations, financial institutions, international organisations, and local communities influence the production, processing, trade, and governance of strategic mineral resources.

According to Singh (2025), critical minerals have become instruments of structural power within the global economy because countries controlling mineral extraction, refining, and processing possess significant geopolitical influence over clean energy supply chains. Unlike fossil fuels, where production and consumption were concentrated among a limited number of countries, critical mineral value chains involve complex global networks characterised by unequal distribution of geological resources, technological capabilities, and processing infrastructure. The uploaded political economy report further explains that global demand for critical minerals is increasing rapidly due to the expansion of renewable energy technologies, while refining capacity remains concentrated in a few countries, particularly China. This concentration creates new forms of economic dependence and strategic competition among nations. For India, the political economy of critical minerals encompasses four interconnected dimensions:

- National resource security;
- Industrial competitiveness;
- Environmental sustainability; and
- Social inclusion.

Although substantial policy attention has been devoted to the first three dimensions, social inclusion—particularly gender equality—remains comparatively underdeveloped.

3.2 Gender Dimensions of the Critical Mineral Value Chain

The critical mineral value chain comprises exploration, extraction, processing, transportation, refining, manufacturing, recycling, and waste management. Women's participation varies considerably across these stages and is often constrained by educational, institutional,

technological, and socio-cultural barriers. In exploration and mining operations, women remain significantly underrepresented due to limited access to technical education, engineering disciplines, and skilled employment. Occupational segregation frequently confines women to administrative, clerical, or informal activities rather than technical and managerial positions. Similarly, within mineral processing industries, women encounter barriers related to recruitment practices, workplace safety, wage inequality, limited career advancement, and restricted access to technical training. However, emerging sectors such as battery manufacturing, mineral recycling, environmental monitoring, laboratory analysis, digital mapping, and renewable energy technologies provide new opportunities for increasing women's participation. These opportunities require investment in adult education, vocational training, digital literacy, and green skills development. From a political economy perspective, gender inequalities within the critical mineral sector are not solely labour market issues but reflect broader institutional arrangements governing access to education, finance, technology, land, and political representation.

3.3 Women in Mining-Affected Communities

Women in mining-affected regions experience the impacts of mineral development differently from men. Although mining can generate employment, infrastructure, and economic growth, it often leads to environmental degradation, including loss of agricultural land, deforestation, water scarcity, biodiversity decline, and increased health and livelihood challenges. In rural and tribal areas, where women depend heavily on natural resources for household and agricultural activities, these impacts disproportionately increase their economic vulnerability and unpaid care responsibilities. Despite being directly affected, women are frequently excluded from land acquisition negotiations, compensation processes, rehabilitation planning, environmental monitoring, and local mining governance institutions. This limited participation reduces their ability to influence decisions affecting their livelihoods and weakens the inclusiveness and sustainability of mineral governance. Promoting women's participation in decision-making, ensuring equitable access to compensation and livelihood opportunities, and strengthening gender-responsive governance are therefore essential for achieving socially just and sustainable critical mineral development.

3.4 Gender Equality and Sustainable Mineral Governance

Recent international policy discussions increasingly recognise that gender equality constitutes an essential component of responsible mineral governance. The uploaded report "The Criticality of Gender Equality in the Race for Critical Minerals" argues that achieving a just energy transition requires integrating gender equality throughout critical mineral supply chains, including exploration, extraction, processing, manufacturing, recycling, and governance.

The report highlights several major gender-related challenges:

- Underrepresentation of women in technical occupations;
- Limited participation in leadership positions;
- Unequal access to vocational training;
- Gender-based discrimination in employment;
- Inadequate occupational safety measures;
- Unequal benefit sharing;
- Insufficient participation in community decision-making.

Conversely, gender-responsive governance contributes to:

- Improved transparency;
- Stronger environmental accountability;
- Better community engagement;
- Inclusive economic development;
- Enhanced social legitimacy of mining projects.

These findings suggest that women's participation should be viewed not merely as a social objective but as an important determinant of governance effectiveness.

3.5 Adult Education as an Instrument of Women's Empowerment

Adult education provides the foundation for integrating women into the emerging green mineral economy. Lifelong learning enhances women's capacity to participate effectively in technical occupations, environmental governance, entrepreneurship, and democratic decision-making.

Key components of adult education include:

- literacy;
- vocational education;
- environmental education;
- financial literacy;
- digital literacy;
- legal awareness;
- entrepreneurship development.

These competencies improve women's ability to engage in mineral-related employment opportunities, monitor environmental impacts, access government welfare programmes, and participate in local governance institutions. The National Education Policy (2020) emphasises lifelong learning and community education as central components of inclusive development. Integrating these educational initiatives with India's critical mineral strategy can create a skilled workforce capable of supporting sustainable resource management.

3.6 Women's Participation in Green Employment

The global transition towards renewable energy is generating new employment opportunities across critical mineral value chains. These include:

- Geological surveying;
- Laboratory testing;
- Battery manufacturing;

- Battery recycling;
- Environmental auditing;
- Renewable energy maintenance;
- Digital resource mapping;
- Sustainable mining;
- Circular economy enterprises.

Women equipped with technical and vocational skills can participate actively in these sectors, thereby contributing to economic diversification and household income generation. Studies indicate that organisations with greater gender diversity often demonstrate higher innovation, improved decision-making, and stronger environmental performance. Consequently, increasing women's participation within critical mineral industries can simultaneously enhance productivity and sustainability.

3.7 Gender-Responsive Governance in India

India has adopted several institutional mechanisms supporting women's empowerment, including:

- Reservation for women in Panchayati Raj Institutions;
- Self-Help Groups (SHGs);
- Mission Shakti;
- National Rural Livelihoods Mission (NRLM);
- Skill India Mission;
- Digital India.

These programmes have significantly improved women's participation in local governance, entrepreneurship, financial inclusion, and community development. However, their integration into mineral governance remains limited. Mineral-bearing districts require stronger institutional coordination between mining agencies, educational institutions, local governments, women's organisations, and civil society groups.

A gender-responsive governance framework should include:

- Mandatory representation of women in mining committees;
- Gender-sensitive environmental impact assessments;
- Targeted vocational training programmes;
- Equal employment opportunities;
- Women's participation in benefit-sharing mechanisms;
- Community monitoring of environmental compliance.

Such measures would improve both governance quality and sustainable development outcomes.

3.8 Gender, Critical Minerals and the Sustainable Development Goals

The relationship between women's empowerment and India's critical mineral strategy directly contributes to several Sustainable Development Goals (SDGs).

Table 2. Linkages Between Gender Equality and Sustainable Development Goals

SDG	Contribution of Gender-Responsive Mineral Governance
SDG 4	Adult education and lifelong learning
SDG 5	Women's empowerment and gender equality
SDG 8	Decent work and inclusive economic growth
SDG 9	Sustainable industrialisation and innovation
SDG 10	Reduced inequalities
SDG 12	Responsible consumption and production
SDG 13	Climate action
SDG 16	Inclusive institutions and participatory governance

Integrating gender equality into India's critical mineral strategy therefore strengthens multiple dimensions of sustainable development simultaneously.

3.9 Proposed Conceptual Framework

Based on the literature and policy analysis, the following conceptual framework illustrates the relationship between adult education, women's empowerment, and sustainable critical mineral governance.

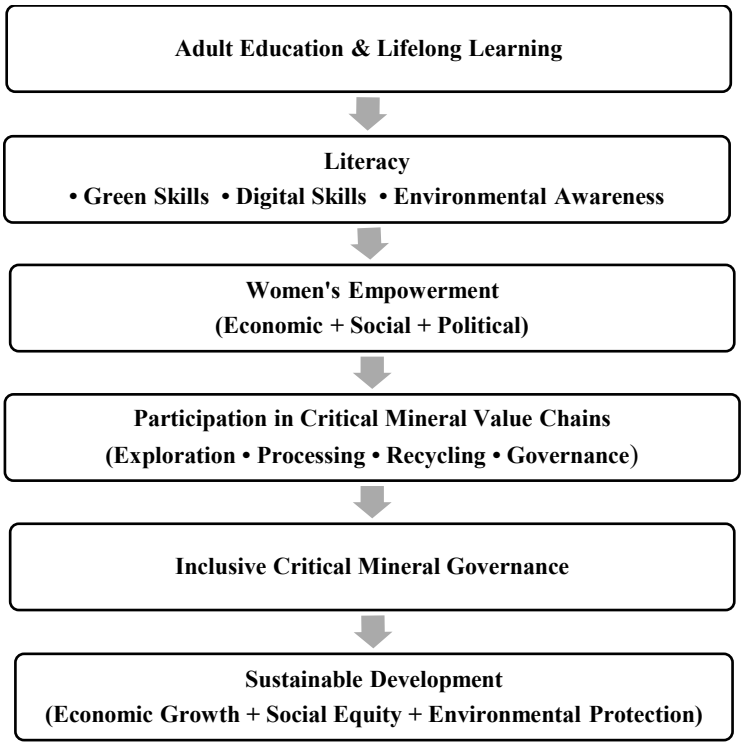

Figure 2. Conceptual Framework Linking Adult Education, Women's Empowerment, and India's Critical Mineral Strategy (Developed by the Author).

The gendered political economy of critical minerals demonstrates that mineral governance cannot be understood solely through economic or technological perspectives. Instead, it reflects broader relationships among political institutions, labour markets, educational systems, environmental governance, and social inclusion. India's critical mineral strategy offers a unique opportunity to integrate gender equality into the emerging green economy through adult education, vocational training, and participatory governance. By strengthening women's capabilities and ensuring equitable participation across critical mineral value chains, India can enhance not only economic competitiveness but also democratic governance, environmental sustainability, and social justice. Consequently, gender-responsive mineral

governance should become a central pillar of India's sustainable development strategy rather than a peripheral social policy consideration.

4. ADULT EDUCATION AS A GOVERNANCE INSTRUMENT

Adult education has evolved from a literacy-oriented programme into a multidimensional instrument for strengthening democratic governance, social inclusion, sustainable development, and community empowerment. Contemporary governance theories recognise that effective institutions depend not only on administrative efficiency but also on informed citizens who possess the knowledge, skills, and confidence to participate actively in decision-making processes. Adult education therefore functions as a governance mechanism by enhancing civic awareness, leadership capacity, legal literacy, and public accountability (Freire, 1970; UNESCO, 2021). In developing countries, particularly India, adult education plays a crucial role in promoting participatory governance by enabling marginalized communities, especially women, to engage in local institutions, access government welfare programmes, understand legal rights, and contribute to sustainable resource management. As India expands its critical mineral sector to support renewable energy and green industrialisation, adult education becomes increasingly important for strengthening community participation in mineral governance and environmental stewardship (Mishra, 2025; Singh, 2026).

4.1 Adult Education and Democratic Governance

Governance is increasingly understood as a collaborative process involving governments, civil society organisations, local communities, and citizens. Democratic governance requires citizens to participate actively in policy formulation, implementation, monitoring, and evaluation. Adult education contributes significantly to this process by developing civic competencies, improving political awareness, and enhancing citizens' understanding of governance institutions (Freire, 1970). According to UNESCO (2021), lifelong learning equips adults with the knowledge and competencies necessary for active citizenship, democratic participation, and sustainable development. Adult education programmes strengthen individuals' understanding of constitutional rights, local governance systems, public service delivery, and environmental responsibilities, thereby increasing their capacity to engage constructively with public institutions. The National Education Policy (Government of India, 2020) similarly recognises adult education as an essential component of inclusive

governance. The policy promotes literacy, vocational education, digital literacy, financial education, environmental awareness, and civic education to empower citizens and strengthen democratic participation. For India, where many critical mineral deposits are located in rural and tribal regions, adult education can significantly improve community engagement in Panchayati Raj Institutions, Gram Sabhas, and District Mineral Foundation (DMF) committees, ensuring that local populations participate meaningfully in decisions regarding mineral exploration, land acquisition, environmental protection, and benefit-sharing (Singh, 2026).

4.2 Adult Education and Civic Participation

Civic participation represents one of the most important outcomes of adult education. It refers to citizens' active involvement in elections, public consultations, local governance, environmental monitoring, community organisations, and policy advocacy. Adult education strengthens civic participation by increasing political literacy, communication skills, and awareness of public rights and responsibilities (Freire, 1970). Studies have consistently demonstrated that educated adults participate more actively in community development initiatives, local governance institutions, and public decision-making processes (UNESCO, 2021). Women who receive adult education are more likely to participate in Gram Sabha meetings, Self-Help Groups (SHGs), Village Development Committees, and local environmental management initiatives. Within the context of India's critical mineral strategy, increased civic participation enables communities to contribute to environmental impact assessments, rehabilitation planning, monitoring of mining operations, and implementation of sustainable development programmes. Such participation enhances transparency and improves the legitimacy of governance processes (Godbole et al., 2026).

4.3 Adult Education, Leadership Development, and Institutional Capacity

Adult education also strengthens governance by developing leadership capabilities among citizens and community representatives. Leadership training enhances decision-making, negotiation, conflict resolution, financial management, and organisational skills, enabling individuals to contribute effectively to local governance institutions (UNESCO, 2021). Freire (1970) argued that education transforms individuals from passive recipients of government policies into active agents of social change. Through critical reflection and participatory learning, adult learners acquire the confidence necessary to challenge unequal power structures

and advocate for equitable development. In mineral-bearing regions, leadership development through adult education can improve community participation in environmental governance, rehabilitation planning, and local development programmes financed through District Mineral Foundations (DMFs). Women leaders trained through adult education programmes can also facilitate dialogue between mining companies, local governments, and affected communities, thereby reducing conflicts and promoting inclusive governance (Singh, 2026).

4.4 Adult Education and Accountability

Transparency and accountability constitute essential principles of democratic governance. Adult education strengthens accountability by enabling citizens to understand public policies, monitor government performance, and demand transparency in decision-making (Freire, 1970). Educated citizens are more likely to utilise mechanisms such as the Right to Information Act, public hearings, social audits, and community consultations to ensure responsible governance. They are also better equipped to understand environmental regulations, monitor mining activities, and participate in public hearings associated with mineral development projects. Within India's critical mineral sector, accountability assumes particular importance because mining projects often involve complex issues related to environmental protection, land acquisition, rehabilitation, revenue distribution, and community welfare. Adult education enables local communities to engage constructively with these governance processes, thereby strengthening institutional transparency and reducing social conflicts (Godbole et al., 2026; Mishra, 2025).

4.5 Adult Education and Women's Empowerment

Women's empowerment represents one of the most significant outcomes of adult education. Lifelong learning enhances women's literacy, technical competencies, financial literacy, digital skills, leadership capacity, and political participation. These capabilities improve women's access to employment, entrepreneurship, public services, and local governance institutions (UNESCO, 2021). Research indicates that educated women participate more actively in Panchayati Raj Institutions, Self-Help Groups, environmental committees, and local development planning. They are also more likely to advocate for investments in education, healthcare, water management, environmental conservation, and community welfare (Government of India, 2020). Within India's emerging critical mineral economy, adult education can prepare women for employment in mineral exploration, laboratory analysis,

battery manufacturing, mineral recycling, environmental monitoring, and renewable energy industries. Such participation contributes not only to gender equality but also to strengthening the human capital required for India's green industrial transition (Mishra, 2025; Pandey, n.d.).

4.6 Adult Education for Sustainable Critical Mineral Governance

The transition towards renewable energy requires governance systems capable of balancing economic development with environmental sustainability and social justice. Adult education supports sustainable mineral governance by improving environmental literacy, promoting awareness of mining regulations, strengthening community participation, and encouraging responsible resource management. Godbole et al. (2026) argue that India's critical mineral strategy should incorporate sustainable governance mechanisms capable of balancing industrial development with environmental protection and community welfare. Similarly, Singh (2026) emphasises that future mineral governance requires stronger institutional coordination, transparent regulatory frameworks, and inclusive public participation.

Adult education contributes to these objectives by enabling communities to:

- Understand environmental legislation;
- Participate in Environmental Impact Assessment (EIA) consultations;
- Monitor mining-related environmental impacts;
- Engage in rehabilitation and resettlement planning;
- Promote sustainable livelihood diversification;
- Participate in green entrepreneurship and circular economy initiatives.

Consequently, adult education functions as a bridge connecting local communities with national governance frameworks, thereby improving the effectiveness and legitimacy of India's critical mineral strategy.

5. SUSTAINABLE DEVELOPMENT PERSPECTIVE

Sustainable development provides the foundation for balancing economic growth, environmental protection, and social equity in the governance of critical minerals. As demand for lithium, cobalt, nickel, graphite, and rare earth elements continues to increase due to the

global transition towards renewable energy and electric mobility, countries must ensure that mineral extraction supports long-term environmental sustainability and inclusive development rather than short-term economic gains. Responsible governance therefore requires integrating economic efficiency with environmental conservation and social justice throughout the critical mineral value chain.

Critical minerals play a dual role in sustainable development. They are essential for clean energy technologies, battery storage systems, and low-carbon industries that contribute to climate change mitigation. However, unsustainable mining practices can result in land degradation, water pollution, biodiversity loss, greenhouse gas emissions, and displacement of local communities. Consequently, sustainable mineral governance should adopt a life-cycle approach that promotes responsible exploration, environmentally sound mining, efficient processing, recycling, and circular economy practices to minimise ecological impacts while maximising economic and social benefits.

The Sustainable Development Goals (SDGs) offer a comprehensive framework for linking critical mineral governance with quality education, gender equality, decent work, responsible production, climate action, and strong institutions. In this context, adult education becomes an important driver of sustainable development by improving environmental literacy, technical skills, digital competence, and civic awareness among local communities. Similarly, women's empowerment strengthens inclusive governance by increasing participation in decision-making, promoting equitable benefit-sharing, and improving environmental stewardship.

For India, achieving net-zero emissions by 2070 will substantially increase the demand for critical minerals, making sustainable governance increasingly important. This requires stronger environmental regulations, responsible mining practices, mineral recycling, and active community participation. Integrating adult education, women's empowerment, and participatory governance into India's critical mineral strategy will enhance resource security while ensuring that economic development remains socially inclusive and environmentally sustainable. Ultimately, such an integrated approach supports long-term national development and strengthens India's transition towards a resilient and sustainable green economy.

6. INTERSECTIONALITY IN MINERAL REGIONS

The concept of intersectionality recognises that social inequalities arise from the interaction of multiple dimensions of identity, including gender, class, caste, ethnicity, age, disability, education, occupation, and geographical location. In mineral-producing regions, these intersecting social factors shape individuals' access to resources, employment opportunities, political participation, education, healthcare, and environmental security. Consequently, the impacts of mining are not experienced uniformly across communities but vary according to existing social and economic inequalities. India's major critical mineral deposits are located predominantly in rural, tribal, and economically disadvantaged regions. These areas often experience multidimensional poverty, limited educational infrastructure, inadequate healthcare services, weak institutional capacity, and restricted access to formal employment. Women belonging to Scheduled Tribes, Scheduled Castes, and economically weaker sections frequently encounter multiple forms of exclusion simultaneously, limiting their ability to participate in governance and benefit from mineral-led development.

The intersection of gender and education represents one of the most significant barriers to inclusive mineral governance. Lower educational attainment restricts women's access to technical occupations within mining industries, reduces awareness of legal rights, and limits participation in environmental decision-making. Similarly, limited digital literacy and financial inclusion reduce women's ability to engage with emerging opportunities in renewable energy, mineral recycling, and green entrepreneurship. Intersectionality also influences environmental vulnerability. Women responsible for household water collection, fuelwood gathering, and subsistence agriculture are disproportionately affected by land degradation, deforestation, declining water quality, and biodiversity loss associated with mining activities. These environmental changes increase unpaid care responsibilities while simultaneously reducing livelihood opportunities, thereby reinforcing existing social inequalities.

Tribal communities represent another important dimension of intersectionality within mineral governance. Indigenous populations often possess valuable ecological knowledge regarding biodiversity conservation, forest management, and sustainable resource utilisation. However, historical marginalisation and inadequate representation within governance institutions have frequently excluded these communities from policy formulation and benefit-sharing mechanisms. Recognising indigenous knowledge systems and ensuring equitable participation

are therefore essential components of socially inclusive mineral governance. Intersectionality also extends to employment within critical mineral value chains. Women from rural and marginalised backgrounds often face barriers related to technical education, transportation, childcare responsibilities, occupational segregation, and workplace discrimination. Without targeted educational interventions and supportive labour market policies, the emerging green economy may reproduce rather than reduce existing inequalities.

Adult education provides an effective mechanism for addressing these intersecting forms of disadvantage. Lifelong learning programmes can simultaneously improve literacy, technical skills, environmental awareness, financial capability, legal knowledge, and digital competence. Such integrated educational approaches strengthen women's capacity to participate in local governance institutions, access employment opportunities, establish enterprises, and contribute to sustainable resource management. Recognising intersectionality also improves policy effectiveness. Uniform policy interventions often fail to address the diverse needs of different social groups. Gender-responsive and socially inclusive governance therefore requires context-specific policies that recognise differences in educational attainment, socio-economic conditions, cultural practices, and geographical location. Integrating intersectional perspectives into India's critical mineral strategy can promote more equitable distribution of development benefits while reducing social exclusion and enhancing democratic participation.

7. POLICY ANALYSIS: TOWARDS GENDER-RESPONSIVE CRITICAL MINERAL GOVERNANCE

India's transition towards a green economy provides an important opportunity to develop a more inclusive and sustainable framework for critical mineral governance. Although recent policy initiatives have strengthened mineral exploration, supply-chain security, and international cooperation, greater emphasis is needed on integrating gender equality, adult education, and participatory governance into policy design. A gender-responsive approach recognises women as active stakeholders across the critical mineral value chain and promotes equal access to education, technical training, employment, leadership, and decision-making. Increasing women's participation not only advances gender equality but also strengthens environmental stewardship, institutional accountability, and community trust.

Adult education should be incorporated as a key component of critical mineral governance. Community learning centres and vocational institutions can provide training in environmental

literacy, sustainable mining, digital skills, financial literacy, entrepreneurship, occupational safety, and legal awareness. These programmes will enhance local capacity to participate in environmental monitoring, public consultations, and green employment opportunities while supporting lifelong learning and community empowerment.

Strengthening participatory governance is equally important. Institutions such as Gram Sabhas, Panchayati Raj Institutions, and District Mineral Foundations should ensure meaningful representation of women, tribal communities, and other marginalised groups. Transparent planning and equitable utilisation of mineral revenues can improve local development outcomes in education, healthcare, infrastructure, and environmental restoration.

Environmental sustainability must remain central to mineral governance through responsible mining practices, gender-sensitive environmental impact assessments, mineral recycling, and climate-resilient resource management. Furthermore, coordinated action among ministries, educational institutions, industry, and civil society is essential for effective implementation. Finally, robust monitoring systems with measurable indicators on women's participation, adult education, environmental performance, and community benefit-sharing will improve accountability and ensure that India's critical mineral strategy contributes to sustainable, inclusive, and equitable development.

8. DISCUSSION

The findings of this study demonstrate that critical mineral governance should be viewed not only through the lens of resource security and industrial competitiveness but also as a multidimensional governance issue encompassing gender equality, adult education, environmental sustainability, and inclusive development. Although India has introduced significant policy reforms to strengthen exploration, supply-chain resilience, and domestic processing of critical minerals, these initiatives have largely focused on economic and strategic objectives (Godbole et al., 2026; Singh, 2026). The analysis indicates that long-term resource security depends equally on strengthening human capital, community participation, and institutional accountability.

A major contribution of this study is the recognition of adult education as a strategic governance instrument. Lifelong learning enhances literacy, environmental awareness, digital competence, financial literacy, and technical skills, enabling local communities to participate

effectively in environmental monitoring, public consultations, and sustainable resource management. In mineral-bearing regions, adult education strengthens community resilience while improving transparency and democratic participation in governance processes. This finding supports the argument that investments in human capital should complement investments in mining infrastructure and technological development (Mishra, 2025).

The study also highlights that women's empowerment is central to sustainable critical mineral governance. Despite increasing participation in education and local governance, women remain underrepresented in mining industries and mineral policy institutions because of unequal access to technical education, occupational segregation, and limited leadership opportunities. Expanding women's access to green skills, vocational education, entrepreneurship, and decision-making positions would not only promote gender equality but also improve environmental stewardship, institutional legitimacy, and inclusive economic growth. These findings are consistent with the policy perspectives advanced by Chadha and Sivamani (2021), who emphasise that sustainable mineral strategies should incorporate inclusive governance and human resource development alongside supply security.

Another important finding is that sustainable development requires balancing economic objectives with environmental protection and social justice. Although critical minerals are indispensable for renewable energy technologies and India's clean energy transition, mining activities may generate land degradation, biodiversity loss, water pollution, and community displacement if not governed responsibly. Therefore, adopting a life-cycle approach that integrates responsible mining, mineral recycling, environmental restoration, and community participation is essential for achieving sustainable development (Pandey, n.d.; Godbole et al., 2026).

The proposed integrated governance framework contributes to the literature by linking critical mineral strategy with adult education, women's empowerment, and participatory governance. Unlike conventional resource governance models that prioritise economic efficiency, this framework emphasises education, gender inclusion, environmental responsibility, and institutional coordination as mutually reinforcing pillars of sustainable development. From a policy perspective, strengthening gender-responsive institutions, expanding green skills programmes, promoting community participation, and improving inter-ministerial coordination can enhance governance effectiveness and support India's transition towards a

resilient and inclusive green economy (Singh, 2026; Mishra, 2025). Overall, the study concludes that integrating adult education and women's empowerment into India's critical mineral strategy will improve governance quality while advancing national commitments to sustainable development and the Sustainable Development Goals (SDGs).

9. CONCLUSION

The study demonstrates that sustainable critical mineral governance extends beyond resource security and industrial development to encompass gender equality, adult education, environmental sustainability, and inclusive governance. As India accelerates its transition towards a green economy, integrating women's empowerment and lifelong learning into critical mineral policies can strengthen institutional effectiveness, community participation, and equitable development. Adult education enhances environmental awareness, technical skills, digital literacy, and civic engagement, enabling communities—particularly women—to participate meaningfully in mineral governance and benefit from emerging green economy opportunities. A gender-responsive governance framework that promotes equal access to education, employment, leadership, and decision-making can improve transparency, accountability, and social justice across the critical mineral value chain. Furthermore, coordinated policy implementation, green skills development, participatory institutions, and sustainable mining practices will support responsible resource management while contributing to national energy security. Ultimately, linking critical mineral strategy with women's empowerment and adult education provides a holistic pathway towards achieving India's sustainable development goals, inclusive economic growth, and resilient democratic governance.

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