ASSESSMENT OF CURRENT PRACTICES IN ENHANCED ROCK WEATHERING AND DEVELOPING GOOD PRACTICES AND A POLICY FRAMEWORK FOR INDIA

Policy Brief

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MANT

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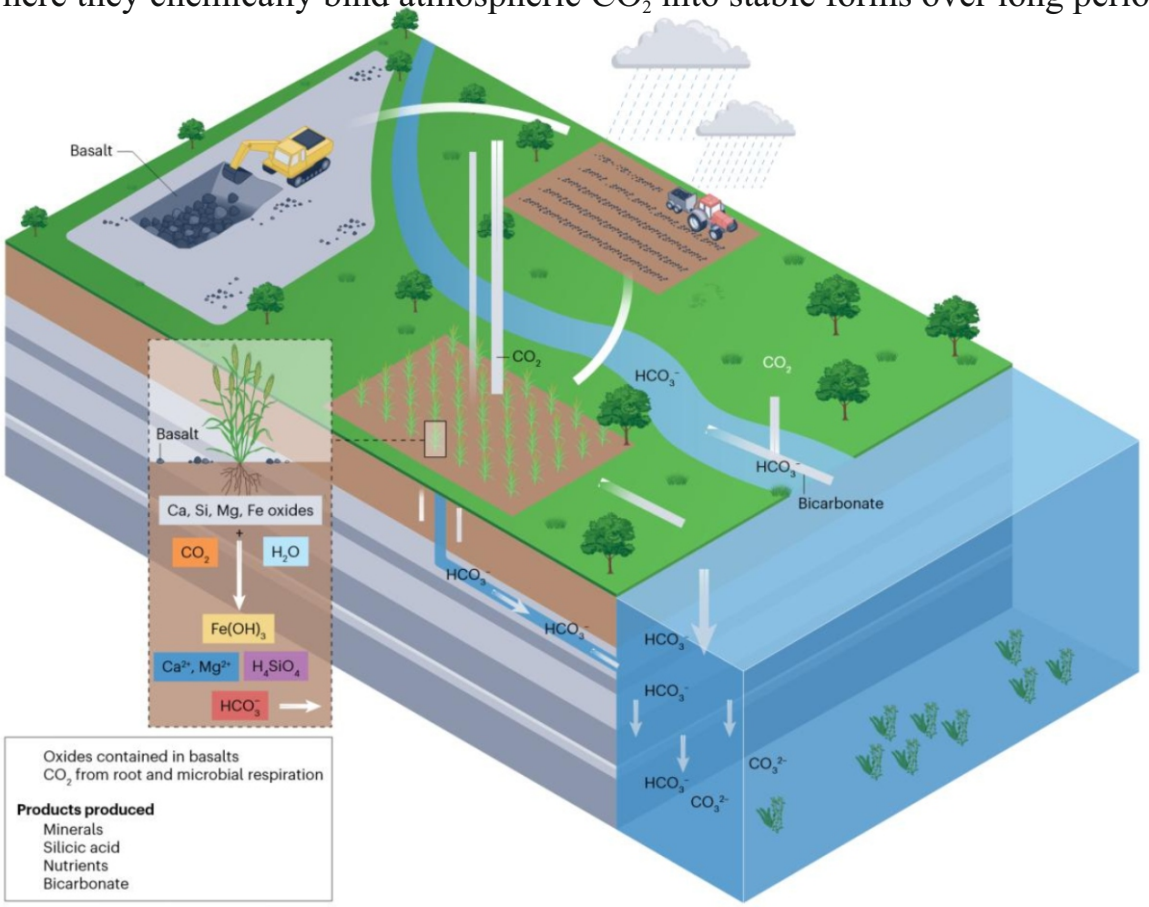
Overview

Enhanced Rock Weathering (ERW) is a timely climate solution that accelerates natural geological processes to remove atmospheric CO_2, especially as emission reductions alone are insufficient. In simple terms, ERW involves applying finely crushed silicate rocks to soils, where they chemically bind atmospheric CO_2 into stable forms over long periods.



Overview of the process of enhanced rock weathering (shown in this case for basalt). Also shown are the basic chemical reactions that lead to the weathering process (reproduced from Beerling et al. 2025)

Potential and Co-Benefits

ERW has significant climate mitigation potential, with estimates indicating removal of hundreds to thousands of gigatonnes of CO_2 this century. It also delivers co-benefits by improving soil health, enhancing nutrient availability, stabilizing pH, and increasing agricultural productivity. These benefits can reduce fertilizer use, support climate resilient agriculture, and improve crop yields. ERW can further enable participation in carbon credit markets, creating new economic opportunities if aligned with formal carbon trading systems.

Challenges and Gaps

However, ERW remains an evolving field with uncertainties around field performance, long-term impacts, and accurate carbon measurement. Alignment with compliance carbon markets is essential for long-term viability beyond voluntary markets. Clear governance frameworks, including formal farmer agreements, are needed to ensure transparency and equitable benefit-sharing. Environmental risks such as dust, toxic elements, and impacts on soil and water require careful monitoring and safeguards. Overall, ERW offers strong potential but requires robust science, policy support, and risk management for responsible scale-up.

Theme	Key Finding
CDR Potential	Global estimates range from >300 Gt CO_2 to 5500 Gt CO_2 during the 21st century. India ranks among the top three nations for ERW potential alongside China and the USA. Possible use of industry by-products like steel slag, crusher wastes, mine tailings, etc. instead of silicate rocks.
Agricultural Co-benefits	Field trials report crop yield increases of approximately 7–77% depending on rock type, soil, and crop. ERW improves soil pH, nutrient availability (Ca, Mg, K, Si, Fe), and reduces dependence on synthetic fertilisers. Improves crop health making climate resilient agriculture possible.
India's Advantages	Extensive suitable rock types (like basalt deposits), large cropland area, tropical climate with high rainfall and temperature, and low operational costs make India highly suited for ERW deployment.
Current Gaps	No long-term peer-reviewed field study from India on ERW in agriculture. Universally accepted methods for measuring, reporting and verification (MRV) of CDR from ERW are absent. Long-term field data remain scarce globally.
Policy Vacuum	India lacks a dedicated ERW policy, ERW-specific MRV standards, and a domestic carbon credit registry. ERW is not recognised under the Carbon Credit Trading Scheme (2024). Additionally, India, similar to many other countries, does not have regulatory guidelines specifying the maximum allowable concentrations of potentially toxic elements in soil.
Environmental Risks	Dust generation, potentially toxic element contamination (Ni, Cr, Pb, Cd, As), soil structure alteration, and potential leaching into water bodies require rigorous monitoring and feedstock screening.

Policy Recommendations

Common recommendations applicable across the ERW life cycle:

- The current study recommends developing a unified MRV protocol aligned with international best practices, covering contaminant testing, energy-use accounting, PTE thresholds, permanence, and additionality.

- Implement strict dust control measures at all stages of the ERW process, with mandatory provision and use of appropriate PPE for all workers, along with life and heath insurance valued at INR 5 lakhs.

The specific recommendations for each step of the ERW process are discussed below:

ERW Feedstock sourcing:

- Prioritise the use of naturally occurring silicate rocks for ERW, while exercising caution with industrial by-products (e.g., steel slag). New mining for ERW should be discouraged; instead, policy should promote the utilisation of existing materials such as quarry waste, crusher by-products, mine overburden, and carefully screened industrial residues, subject to stringent quality controls.

- Designate the Geological Survey of India (GSI) as the nodal authority for ERW feedstock governance, leveraging its expertise in rock geochemistry. In coordination with the Directorate General of Mines Safety (DGMS), GSI should identify, classify, and periodically update approved feedstock categories, including mine tailings and overburden.

- Establish strict environmental and health safeguards by prohibiting the use of feedstocks containing elevated levels of potentially toxic elements (PTEs), sulphides, asbestos, or radioactive materials. This should be supported by nationally standardised thresholds for permissible PTE concentrations in soils, developed with technical inputs from ICAR, State Agricultural Universities (SAUs), GSI, and CGWB.

- Strengthen the evidence base through targeted research and development funding led by the Department of Science and Technology (DST), focusing on the carbon dioxide removal (CDR) potential of various rock types and industrial by-products, as well as their agronomic co-benefits.

- ERW companies should establish escrow mechanisms to fund afforestation and ensure dedicated resouce allocation.

Feedstock Processing and Conditioning:

- Encourage targeted research into the use of organic additives (e.g., carbonic anhydrase) to enhance ERW efficacy; however, their deployment should be approached with caution. Any such additives should undergo rigorous testing and certification by recognized institutions such as ICAR to ensure both safety and agronomic effectiveness before field application.

- It is advisable to strengthen regulatory oversight of crushing and grinding operations by mandating Environmental Impact Assessment (EIA) clearance, particularly for large-scale facilities. Additionally, operators should be required to obtain “Consent to Establish” and “Consent to Operate” from the relevant State Pollution Control Boards (SPCBs) under the Air Act, 1981, and Water Act, 1974, to ensure compliance with environmental norms.

- Dust management should be treated as a critical operational priority. Standard practices should include the use of water sprays during and after comminution, enclosed crushers (especially for large-scale operations), and installation of dry air extraction systems (e.g., pulse jet bag filters). Safe handling measures, such as storing rock powders in closed containers, should be enforced to minimize dust exposure and associated risks.

- A robust inspection regime is recommended, including biannual inspections by relevant geological, environmental, and mining authorities. At least one inspection should be scheduled prior to the monsoon to assess risks related to erosion, runoff, and potential leaching into groundwater and surrounding soils, ensuring proactive environmental risk management.

Transportation and Supply Chain Emissions:

- Promote low-emission and efficient logistics for ERW feedstock transport. This includes prioritising transport modes with lower carbon footprints (e.g., rail) and vehicles powered by renewable or cleaner energy sources over conventional fossil fuel-based options.

- In the absence of dedicated ERW transport regulations, it is strongly recommended that transportation practices align with the provisions of the Fly Ash Notification, 1999 (and its subsequent amendments). Accordingly, ERW feedstocks should be transported only in closed bulkers or adequately covered vehicles (e.g., with tarpaulin).

- Mechanised loading and unloading should be preferred to minimize human exposure and improve efficiency; Dust control measures—including water sprays, dry air extraction systems (e.g., pulse jet bag filters or cyclonic separators), proper dust covers, road watering, and wheel-wash stations—should be implemented at all stages of loading, unloading, and transit.

Field Application:

- Promote targeted deployment of ERW on barren and degraded lands to enhance soil quality, enable productive land use, and support carbon sequestration, while strictly limiting its application to sites with clear, undisputed ownership and avoiding sensitive or contested areas.

- Mandate robust governance frameworks anchored in transparent, enforceable agreements between project developers and landowners. These should clearly define roles, application protocols, benefit-sharing (including carbon credits), data obligations, and dispute resolution. Securing Free, Prior, and Informed Consent (FPIC) is essential; all project details, risks, and benefits should be communicated in local languages using accessible formats to ensure informed participation.

- Strengthen local institutional oversight through proactive engagement with Panchayats, and irrigation and watershed authorities to ensure alignment with local priorities and safeguard water systems and community interests.

- Mechanised spreading should be preferred. Application should occur under conditions that limit dust dispersion, supported by water misting, and exclude aerial methods. Temporary buffer strips should be maintained through at least one monsoon cycle to mitigate runoff risks.

- Define clear triggers for corrective action: any indication of contaminant buildup, adverse soil changes, or risks to crop safety should result in immediate suspension of ERW application and remedial measures. Continuous oversight by ICAR and district agriculture authorities is critical to ensure long-term environmental safety and agronomic viability.

- ERW developers should maintain escrow funds to insure against crop losses and long-term productivity risks.

Long-term Effectiveness and Impact Monitoring:

- Prioritise research on long term impact on environment and crops in Indian conditions through DST and other institutions.

- Institute periodic regulatory inspections with authority to suspend or halt ERW projects if environmental or social risks are identified. MRV findings should be transparent and communicated to local Panchayats and landowners in local languages**.** Local grievance redressal mechanisms should be integrated via Panchayats to address dust, water, or soil concerns.

- Baseline and periodic assessments of soil and crop health—covering key physico-chemical parameters and potentially toxic elements—should be conducted alongside the use of control plots. Biannual testing should be standard practice.

- ICAR could test crops before each harvest to monitor bioaccumulation, with harvesting halted if thresholds are exceeded.

- All MRV data, including carbon credit calculations, should be publicly accessible and updated every six months to ensure transparency.

- Collaboration with Central Ground Water Board and watershed authorities for down-stream impact monitoring.

- Provide for a scheduled, comprehensive review of the policy every five years, supported by an independent scientific advisory panel and mandatory public reporting. In addition, incorporate a science-triggered emergency revision clause enabling immediate policy amendments.

Financial and regulatory levers:

- Integrate ERW into climate and agricultural frameworks, establishing a dedicated inter-agency task force under the NITI Aayog or BEE or MoEFCC for coordinated governance and implementation.

- Carbon Credit Certificates (CCC) should be issued against ERW projects and be allowed to be traded following the current Perform Achieve and Trade (PAT) scheme and eventually within the framework of the Carbon Credit Trading Scheme (CCTS).

- Consider including ERW under CSR provisions and integrating its carbon removal reporting into BRSR/ESG frameworks to mobilize private sector participation and enhance transparency.

- Integrate ERW into the National Mission for Sustainable Agriculture and Soil Health Mission to support climate-smart soil management, while incentivizing farmers through PM Kisan Samman Nidhi and promoting ‘fertilizer-free’ labelling. Link ERW adoption to crop insurance, incentivizing farmers under PM Fasal Bima Yojana.

- Public funding for ERW procurement and initiatives could be facilitated through banks, including SBI and NABARD, as well as private financial institutions. Additionally, the DST should support research and development to advance ERW technologies and scientific understanding.

- Linking ERW to Pradhan Mantri Fasal Bima Yojana can reduce farmer risks and incentivize adoption.

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