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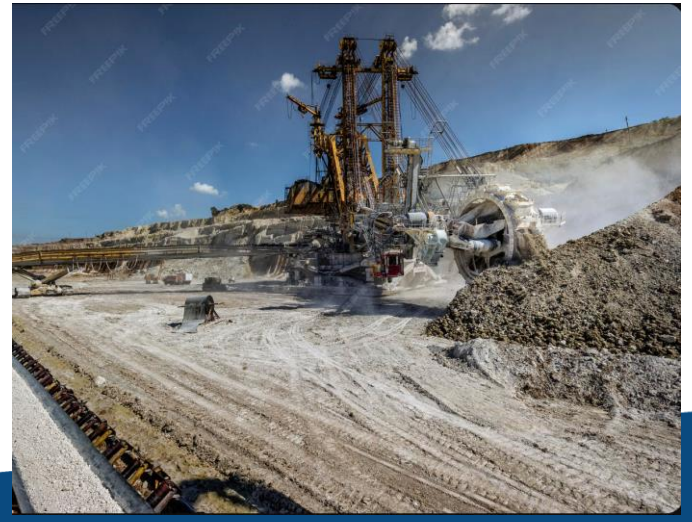
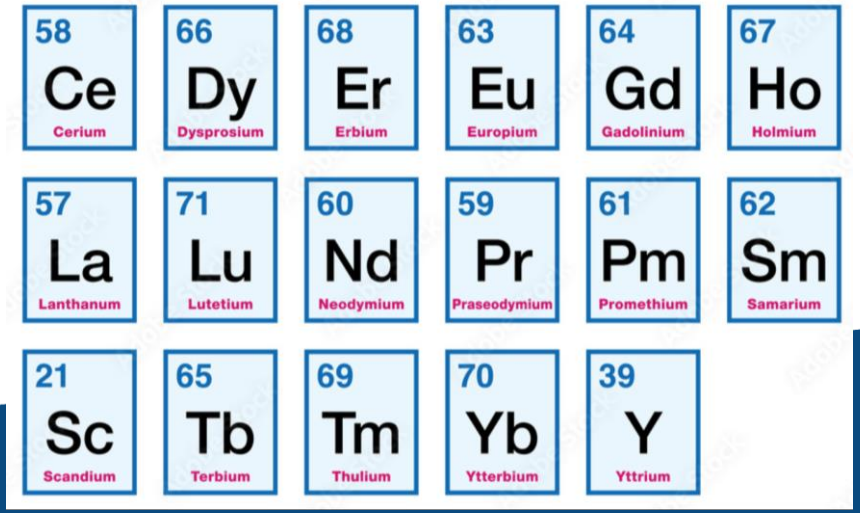
INNOVATING FROM WASTE TO RESOURCES: TECHNOLOGIES FOR RECOVERING VALUABLE MINERALS FROM TAILINGS AND WASTE DUMPS





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Presentation Outline

- Title and Introduction
- The Waste Challenge in Mining
- Circular Economy in Context: Technologies for remining and reprocessing
- Case Studies (Migori, Kwale, Tanzania, South Africa)
- Beyond Metals in Circular Economy
- Policy and Investment Framework
- Strategies for practical participation
- Conclusion and Call to Action

What are the issues with Mine Wastes

“The mining industry produces over 100 billion tonnes of waste annually, 10 per cent of which is tailings. These are generally stored in an increasing number of high-risk tailings dams, posing permanent environmental and safety hazards (Vuillier et al., 2021).”

The Geopolitics Fueling the REE and CRM Agenda

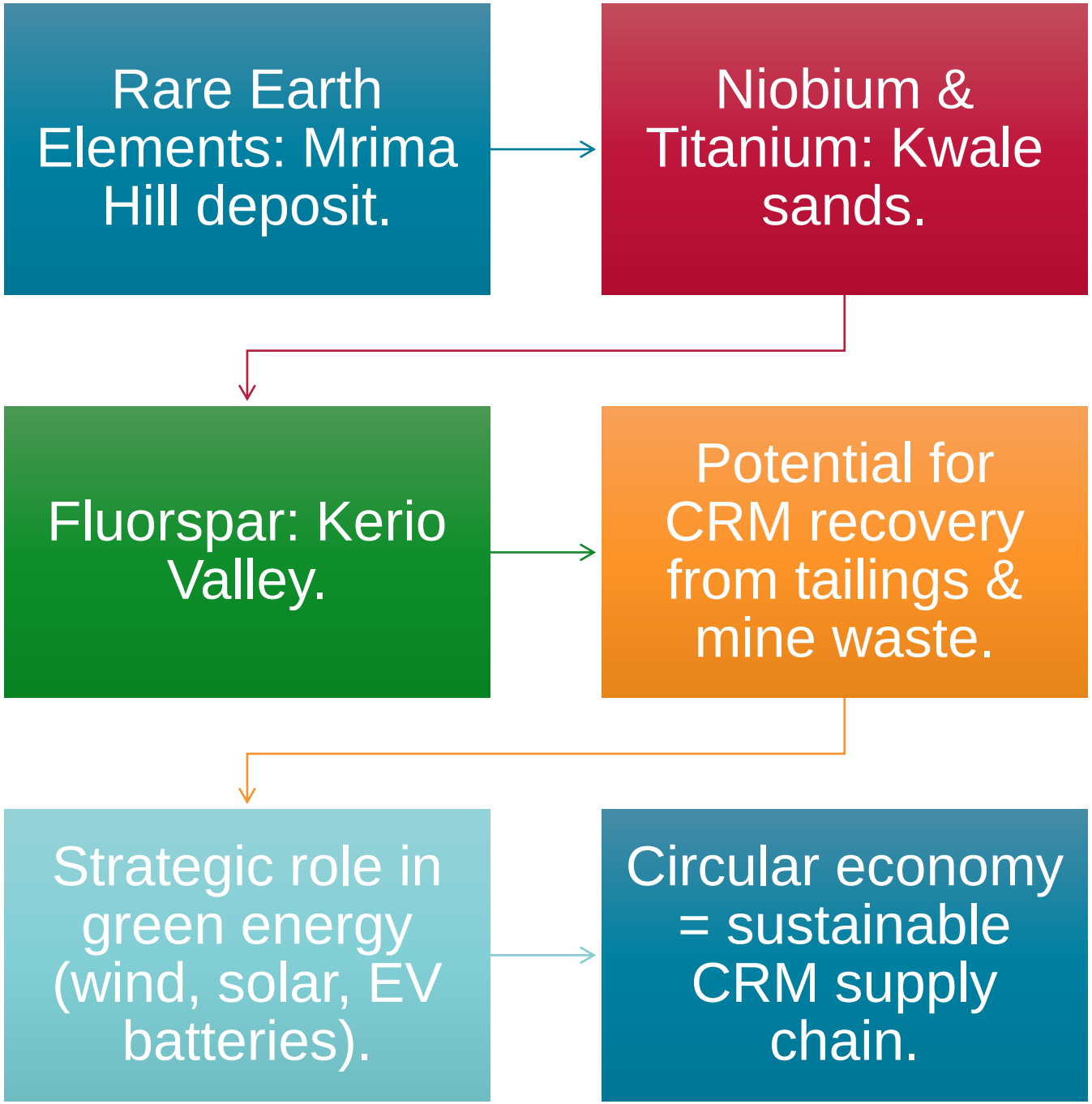
By **2030**, global demand for **cobalt,** essential for rechargeable lithium-ion batteries is projected to **triple**, yet supply is only growing at a weak **1% CAGR (2023–2030)**, creating a huge shortfall.

A similar squeeze is unfolding with **rare earth elements (REEs)** like lanthanum and cerium, where **97% of supply comes from China**, which has already started restricting exports.

China also dominates **tungsten**, a metal critical to boosting the efficiency of **solar PV cells**, and has begun curbing global flows.

With primary sources constrained, the smarter opportunity is **re-mining tailings,** unlocking new revenue, reducing waste, and strengthening ESG performance all at once.

Critical Raw Materials (CRM) Opportunities in Kenya



Technologies for Tailings Reprocessing

Gravity Separation – shaking tables, spirals (Migori gold recovery).

Flotation – sulfides, mineral sands.

Hydrometallurgy – cyanide leaching, (Tanzania copper projects).

Pyrometallurgy – smelting waste concentrates (Zambia cobalt recovery).

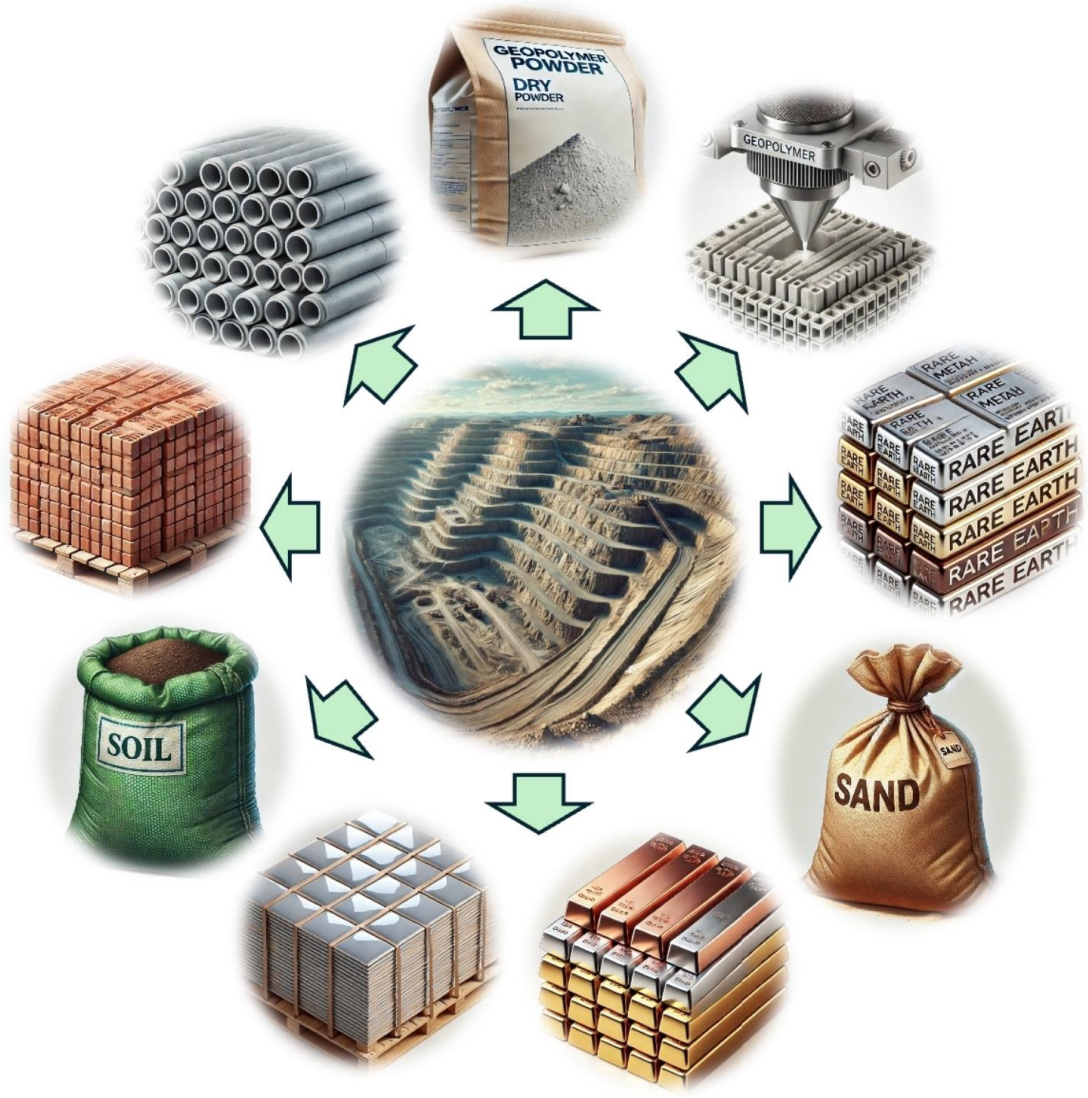
Phytomining- using plants to extract critical minerals (Freiberg).

Bioleaching- Using microorganisms (bacterials) to feed on CRM or REE (Freiberg).

Geopolymerization – tailings into eco-building materials.

Beyond Metals: Expanding Value Chains

- Construction materials (cement, bricks from tailings).
- Fertilizer and soil amendments.
- Renewable energy integration for reprocessing plants.
- Example: South Africa reuses gold tailings for brick manufacturing.

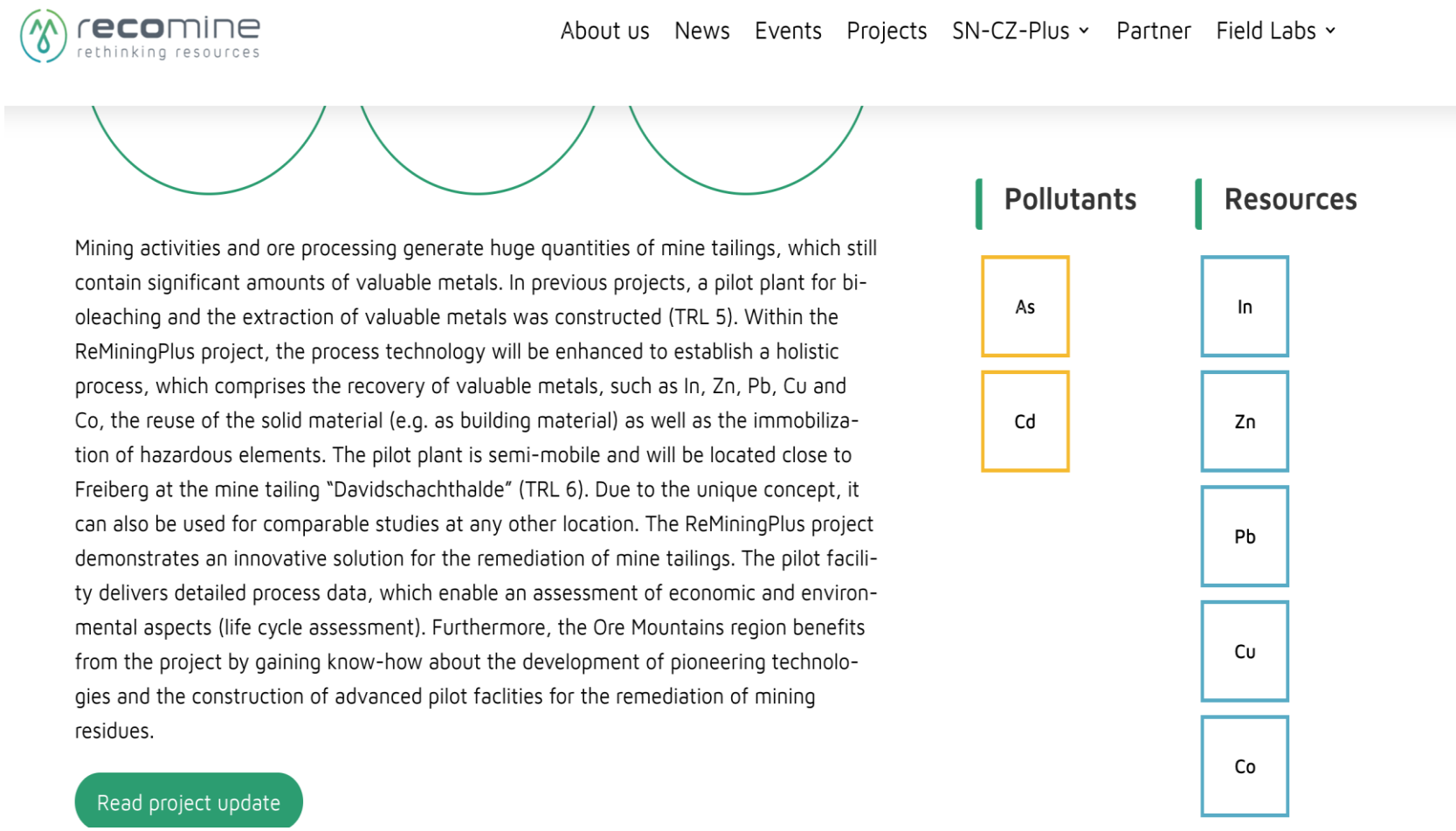


Germany: Pioneering Re-Mining and Circularity

- Germany invests heavily in re-mining abandoned sites.
- Lusatia lignite mines transformed into renewable energy hubs.
- Tailings repurposed into construction aggregates.
- High-value metals recovered from historic mine wastes- Freiberg.
- Supported by EU Green Deal and Horizon Europe programs.

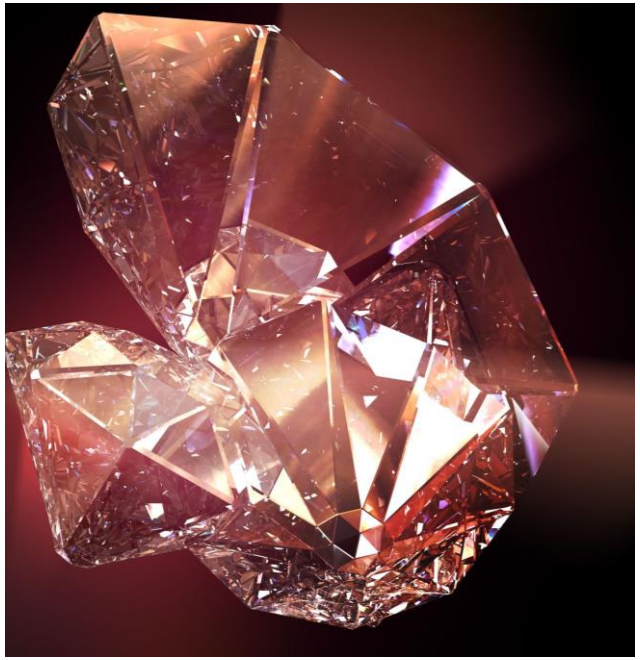
Germany: Economic Benefits of Circular Mining

- Circular mining generates €1.7 billion annually in added value.
- Thousands of jobs in reprocessing, construction materials, and green tech.
- Re-mining supports energy transition (critical raw materials for batteries, renewables).



REEs and CRMs Associated with Gemstones and Gold in Kenya- Specific Cases

- Gemstones (Taita-Taveta, Baringo, Kitui, Turkana, Kwale)
- Associated CRMs:
  - Niobium (Nb) and Tantalum (Ta): Often found in pegmatites, which are also sources of gemstones like tourmaline, beryl, and garnet.
  - Lithium (Li): Also present in spodumene and lepidolite pegmatites associated with gem-bearing rocks.
  - Rare Earth Elements (REEs): Some garnet-rich rocks and pegmatitic feldspars host trace REEs such as yttrium (Y), cerium (Ce), lanthanum (La).



Gold Mines (Migori, Kakamega, Nandi, Siaya)

- **Associated CRMs:**
  - **Arsenic (As), Antimony (Sb):** Common in sulfide ores (arsenopyrite, stibnite) linked to gold mineralisation.
  - **Tungsten (W):** Scheelite sometimes associated with gold-bearing quartz veins.

- Migori gold belt shows sulfide-associated gold deposits with potential for recovering **arsenic, antimony, and tungsten** as by-products. **So, how well is Kenya participating (now and future) in the electronics, semiconductors, Alloys, and glass value chain?**

Strategies to Obtain these Resources

1. Integrated Exploration and Characterisation

•Multi-element exploration: When mapping gemstones or gold, include geochemical assays for REEs, Nb, Ta, Li, Sb, etc.

•Tailings analysis: Many old gold and gemstone processing sites still hold traces of CRMs, a circular economy opportunity for exploitation.

2. By-product Recovery

•Gold Mines:

- Recover arsenic, antimony, and tungsten during sulfide processing (flotation, roasting, hydrometallurgy).

•Gemstone Pegmatites:

- Extract Nb-Ta concentrates and lithium minerals alongside gemstones through selective mining and gravity separation.

Strategies to Obtain these Resources

3. Advanced Processing Technologies

•Flotation and Gravity Separation: For coltan, scheelite, and lithium-bearing minerals.

•Hydrometallurgy (acid/alkali leaching, solvent extraction): For Nb, Ta, and REEs from pegmatite or altered host rocks.

•Bioleaching: Research into low-cost bacterial leaching of REE-bearing minerals is ongoing in Freiberg and could be applied in Kenya.

4. Circular Economy Approaches

•Tailings Reprocessing: Analyze historical tailings from gemstone cutting and gold milling plants for recoverable CRMs.

•Recycling Value Chains: Encourage gemstone offcuts and gold-processing waste to be reintegrated into CRM recovery chains

Strategies to Obtain these Resources

5. Policy and Partnerships

- Establish pilot projects (e.g., in Migori and Taita-Taveta) for CRM recovery.
- Collaborations with universities, especially TTU, and mining companies, governmental bodies for mineralogical studies. **Rockland Mine??**
- Attract investment via **green financing** since CRMs are essential for renewable energy technologies (batteries, EVs, solar, wind).

The Circular Economy Opportunity

Valuation of what Kenya could earn by tapping CRMs/REEs tied to gemstones and gold (plus circular re-mining from tailings)- Mind travel

Scenario	Opportunity	Throughput (Mt/yr)	Output	Output Unit	Revenue (US$M)	EBITDA (US$M)	Royalty+Levy (US$M)	Direct Jobs
Conservative	Gold tailings reprocessing	1.5	16879.1	oz Au	59.1	26.6	4.1	300
Conservative	Nb-Ta (pegmatite & by-product)	0.1	0	t Ta2O5	0	0	0	15
Conservative	Tungsten by-product (scheelite)	0.2	0.2	t WO3	0.8	0.3	0.1	24
Conservative	Lithium (SC6) small-scale recovery	0.05	0.6	t SC6	0	0	0	6
Conservative	Techno-soils & aggregates from tailings	1	1000000	t products	8	8	0.6	100
Conservative	**TOTAL**				**67.9**	**34.9**	**4.8**	**445**
Base case	Gold tailings reprocessing	2.5	28131.9	oz Au	98.5	44.3	6.9	500
Base case	Nb-Ta (pegmatite & by-product)	0.2	0	t Ta2O5	0	0	0	30
Base case	Tungsten by-product (scheelite)	0.4	0.4	t WO3	1.7	0.6	0.1	48
Base case	Lithium (SC6) small-scale recovery	0.1	1.2	t SC6	0	0	0	12
Base case	Techno-soils & aggregates from tailings	2	2000000	t products	16	16	1.1	200
Base case	**TOTAL**				**116.2**	**60.9**	**8.1**	**790**
High ambition	Gold tailings reprocessing	4	45011	oz Au	157.5	70.9	11	800
High ambition	Nb-Ta (pegmatite & by-product)	0.35	0.1	t Ta2O5	0	0	0	52
High ambition	Tungsten by-product (scheelite)	0.6	0.6	t WO3	2.5	0.9	0.2	72
High ambition	Lithium (SC6) small-scale recovery	0.2	2.4	t SC6	0	0	0	24
High ambition	Techno-soils & aggregates from tailings	3	3000000	t products	24	24	1.7	300
High ambition	**TOTAL**				**184.1**	**95.8**	**12.9**	**1248**

Kenya: Jobs and Revenue Potential

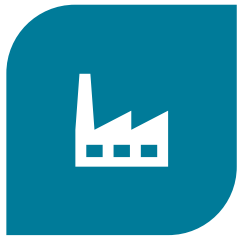
Migori gold tailings + Kwale mineral sands tailings could generate $150–200M in new revenues annually.

5,000–7,000 direct jobs in reprocessing, 15,000+ indirect jobs (logistics, construction, services).

Tax revenues and royalties supporting local counties.

Circular mining can boost GDP contribution of mining from 1% to 3–4%.

Policy and Investment Enablers- How to Get There



TAX INCENTIVES FOR REPROCESSING PROJECTS.

PPPS & CLIMATE FINANCE FOR PILOT PLANTS.

CLEAR FRAMEWORKS FOR TAILINGS RE-MINING.

COMMUNITY BENEFIT-SHARING MODELS.

TANZANIA MODEL: REGISTERED PLANTS FOR ARTISANAL TAILINGS PROCESSING.

Economic Benefits

Cutting Costs and Liabilities – Through reducing the size of tailings storage facilities, companies save on costly long-term monitoring, repairs, and closure activities.

New Revenue Streams – Repurposed mine waste can become valuable products like construction materials, techno-soils, or recovered metals, creating new income for companies and partners.

Boosting Local Economies – Building processing and manufacturing plants near mines creates local jobs, supports SMEs, and stimulates growth in mining communities

Environmental Benefits

Reduced Environmental Risks – Smaller tailings storage facilities mean lower risks of dam failures and pollution incidents.

Smarter Resource Use – Repurposed tailings replace the need for quarrying fresh rock, cutting down the footprint of mining and aligning with circular economy principles.

Restoring Nature – Using waste to create techno-soils supports land rehabilitation, improves ecosystems, and helps restore biodiversity.

Social Implications

- **Job Creation and Skills Growth** – New industries around mine wastes can create sustainable employment and skill-building opportunities for host communities in Kenya.

- **Stronger Communities** – Circular mining hubs can transform mining regions into notable economic centres, improving living standards.

- **Trust and Collaboration** – Demonstration of sustainable practices can build community trust, strengthen investor confidence, and improve the industry's social license to operate.

Conclusion – Call to Action

WASTE IS WEALTH: WHAT WAS ONCE CONSIDERED WASTE CAN NOW BECOME A DRIVER OF **ECONOMIC GROWTH AND ENVIRONMENTAL SUSTAINABILITY**.

PROVEN AND PRACTICAL: WITH **SIMPLE, SAFE, AND TESTED TECHNOLOGIES**, WE CAN CUT COSTS, REDUCE RISKS, AND UNLOCK NEW REVENUE STREAMS.

BROADER IMPACT: TRANSFORMING MINE WASTE REDUCES HIGH-RISK TAILINGS DAMS, CONSERVES SCARCE RAW MATERIALS, CREATES JOBS, AND STRENGTHENS COMMUNITY TRUST.

SHARED RESPONSIBILITY: SUCCESS DEPENDS ON **COLLABORATION** — MINING COMPANIES, REGULATORS, RESEARCHERS, AND LOCAL COMMUNITIES MUST WORK TOGETHER.

THE MOMENT IS NOW: SO, EMBRACING CIRCULAR MINING TODAY, KENYA CAN BUILD A **PROFITABLE, RESILIENT, AND GREENER FUTURE** FOR ITS PEOPLE AND INDUSTRIES.

Asante Sana

Danke

Thank you for your attention