
Mining Asset Valuation Methodologies Under Responsible Mining, Towards Sustainable Mining and IFRS Sustainability Standards

Khurelbaatar Batjargal¹, Nyamaa Dulamsuren², Ser-Od Bayaraa³

¹ National University of Mongolia, Business School, Department of Accounting

² Corresponding author, National University of Mongolia, Business School

³ School of Applied Sciences, Mongolian University of Science and Technology

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Abstract

Certain types of mineral resources, such as rare earth elements and uranium, continue to face strong local opposition when exploration and mining activities are conducted in areas important for social, agricultural, and livestock activities, as well as river basins. One approach to bridging the expectations gap among stakeholders is to accurately evaluate and quantify the returns from these mineral assets. Achieving this requires improving and redesigning mineral asset valuation methods within the framework of sustainable mining initiatives and sustainability reporting standards. Integrating TSM into mining-asset valuation links ESG performance directly to financial outcomes, stabilizing cash flows, reducing risk, and supporting higher, sustainability-aligned asset valuations. Integrating TSM into mining-asset valuation enhances accuracy, reduces risk, and aligns financial assessments with long-term sustainability performance, strengthening both investor confidence and responsible mining practices.

Keywords: Mining assets, Valuation methodologies, Responsible mining, Towards sustainable mining (TSM), IFRS Sustainability Standards

1. Introduction

Today, we are working in a situation where we need to demonstrate and improve how organizations and countries are participating in implementing this strategic goal, rather than each person understanding sustainability differently.

The concept of Responsible Mining (RM) is developed by industry, Non-Governmental Organization (NGO), and academic initiatives as a response to environmental, social, and governance concerns in the mining sector.

Namely, International Council on Mining and Metals (ICMM), established in 2001, is often credited with formalizing corporate responsibility and sustainable development principles for mining companies globally that members commit to ethical, environmentally responsible, and socially inclusive practices, etc.

Towards Sustainable Mining (TSM) is a sustainability performance system developed by the Mining Association of Canada (MAC) in 2004. It was created in response to increasing public scrutiny of mining operations in the 1990s and early 2000s, particularly concerns related to environmental impacts, tailings dam failures, Indigenous rights, and community trust.

Currently, TSM has expanded to include subjects that Water Stewardship Protocol (2020), Indigenous & Community Relationships Protocol, Climate Change Protocol (2021), Integration with global ESG reporting (IFRS S1/S2, GRI, ICMM), Stronger standards for tailings governance aligned with the Global Industry Standard on Tailings Management (GISTM)

TSM became a global mining sustainability standard, adopted by national mining associations worldwide: Finland (2015), Argentina (2016), Botswana (2017), Philippines (2017), Brazil (2019), Spain (2022), Australia (2023), Mongolia (2015).

The IFRS Sustainability Disclosure Standards—introduced by the International Sustainability Standards Board (ISSB) in June 2023 - provide a global baseline for consistent, comparable, and investor-focused sustainability reporting. The ISSB was created under the IFRS Foundation to address fragmented ESG reporting practices and to integrate sustainability with financial disclosure.

2. Mining assets valuation methodologies under Sustainable Mining

2.1. Responsible mining

NGOs in the 1990s helped define what “responsible” mining should entail. NGOs and Civil Society emphasized transparency, community engagement, and environmental protection. The Responsible Mining Foundation (RMF), established in 2008, developed the Responsible Mining Index, providing systematic benchmarking of mining companies’ ESG practices. RMF operationalized the concept with measurable indicators.

Academic influence, Scholars like Hilson (2000), Jenkins (2004), and Yakovleva (2005) contributed to defining responsible mining through research on corporate social responsibility in the mining sector, emphasizing ethical, environmental, and social obligations beyond legal compliance.

RM refers to the set of principles, practices, and governance mechanisms that ensure mining is ethical, environmentally sustainable, socially equitable, and economically beneficial across the entire mining lifecycle. It is broader than legal compliance and focuses on global best practice performance, transparency, and stakeholder trust.

Table 1. Globally recognized concepts of Responsible Mining

Concepts	Activities	Linked Frameworks
<i>Environmental Stewardship</i>	Water, biodiversity, tailings, climate	ICMM, TSM, ISO 14001
<i>Social Responsibility</i>	Community benefits, Indigenous rights	IFC, UNDRIP, IRMA
<i>Human Rights</i>	FPIC, labor rights	UNGP, ILO
<i>Health & Safety</i>	Zero harm, critical controls	ICMM, TSM
<i>Ethical Governance</i>	Anti-corruption, integrity	EITI, OECD
<i>Transparency</i>	ESG reporting, tax disclosure	GRI, IFRS S2
<i>Stakeholder Engagement</i>	FPIC, dialogue	IFC PS1, IRMA
<i>Local Economic Benefits</i>	Local procurement, jobs	SDGs
<i>Supply Chain Responsibility</i>	Due diligence, conflict minerals	OECD, EU regulations
<i>Life-of-Mine Planning</i>	Full-cycle ESG	ICMM
<i>Tailings Governance</i>	GISTM compliance	GISTM 2020
<i>Closure & Legacy</i>	Reclamation, bonds	ICMM, IRMA

Source: Researcher's summary

Responsible mining principles influence mineral asset valuation by requiring analysts to incorporate environmental, social, and governance (ESG) factors into financial and technical assessments. Standards such as the **ICMM Principles (ICMM, 2020)**, **IFC Performance Standards (IFC, 2012)**, and the **Global Industry Standard on Tailings Management (GISTM, 2020)** emphasize stronger environmental protection, community engagement, and risk management. These expectations lead valuation practitioners to adjust cash flows, discount rates, and risk factors to reflect higher compliance costs, rehabilitation liabilities, carbon pricing, permitting risks, and community-related delays. Research shows that ESG risks can materially affect mining project value, weighted average cost of capital, and long-term cash flow certainty (**EY Global Mining & Metals, 2023; McKinsey & Company, 2021**). Conversely, responsible mining practices can enhance value by improving the social license to operate, reducing regulatory uncertainty, and increasing access to capital from ESG-focused investors (**PRI, 2020; OECD Responsible Business Conduct Guidelines, 2018**). Therefore, responsible mining shifts valuation methods toward a more holistic, risk-adjusted framework that reflects sustainability performance and long-term asset resilience.

2.2. Towards Sustainable Mining

TSM is a sustainability program developed by the **Mining Association of Canada** in **2004** in response to growing public, regulatory, and investor expectations for responsible mining. It was created to provide a standardized, transparent framework for assessing and reporting mining companies' environmental and social performance at the facility level.

Initially, TSM focused on areas such as tailings management, energy use, safety, and community engagement. Over time, the program expanded to include water stewardship (2013), biodiversity conservation (2014), and, later, Indigenous and community relationships.

Beginning in **2015**, mining associations in other countries started adopting TSM, including Finland, Argentina, Botswana, Spain, Norway, Brazil, and the Philippines, making it a **globally recognized** sustainability standard.

Today, TSM is one of the leading frameworks for responsible mining, known for its **third-party verification, public performance reporting**, and its focus on continuous improvement of mining operations.

Table 2. TSM components effect to finance

TSM Component	Financial Effects
<i>Tailings Management</i>	CAPEX & OPEX for upgrades; reduces liability risk
<i>Energy & GHG</i>	CAPEX for renewable/efficient tech; OPEX savings; lower carbon costs
<i>Safety & Health</i>	OPEX for training/PPE; lower insurance & compensation costs
<i>Water Stewardship</i>	CAPEX & OPEX for water systems; avoids fines & disruptions
<i>Biodiversity</i>	CAPEX/OPEX for restoration; reputational value
<i>Indigenous & Community Relations</i>	CAPEX/OPEX for programs; avoids protests; investor confidence
<i>Crisis Management</i>	OPEX for drills; reduces financial losses from emergencies
<i>Tailings/Waste/Closure</i>	Increased provisions; CAPEX/OPEX for progressive rehabilitation
<i>Public Reporting</i>	OPEX for verification/reporting; improves access to capital
<i>Continuous Improvement</i>	Long-term CAPEX/OPEX; reduces ESG-related financial risk

Source: Researcher's summary

TSM is practical, operationally focused, to provide a standardized framework for assessing and reporting sustainability performance at the mine-site level. It emphasizes **tailings management, water stewardship, safety, energy efficiency, and community engagement**, with third-party verification and annual public reporting (MAC, 2023).

Beyond general ESG-finance research, a growing literature focuses specifically on how environmental and social risk impacts mining valuation. Azadi et al. (2020) provide a systematic review of environmental risk factors in mining, concluding that tailings management, water usage, biodiversity impacts, and closure liabilities have significant influence on both cash-flow stability and discount-rate determination. Tailings management failures, in particular, have been shown to produce multibillion-dollar losses, leading investors and insurers to place increasing scrutiny on mine governance systems such as TSM (ICMM, 2021).

Professional valuation and consulting reports reinforce these academic findings. KPMG (2020) argues that ESG performance, especially in areas governed by TSM, affects valuation through three channels: (1) operating costs and capital expenditures associated with sustainability improvements, (2) reduction of long-term liabilities and catastrophic risk, and (3) adjustments to the discount rate due to reduced risk premiums. Deloitte (2020) similarly identifies ESG as a dominant driver of mining M&A valuation, noting that assets with weak sustainability performance face a material “brown discount” in transaction multiples, while high-performing assets under frameworks such as TSM can attract premiums.

Sensationalistic (2019) provides quantitative evidence that ESG risk scores—many of which overlap with TSM indicators—correlate strongly with default probability, influencing both market-based valuations and the pricing of corporate debt for mining companies. This linkage further demonstrates that sustainability frameworks shape investor expectations and therefore valuation parameters.

2.3. IFRS Sustainability Standards

The IFRS Sustainability Disclosure Standards (SDS), including IFRS S1 (General Sustainability Disclosures) and IFRS S2 (Climate-related Disclosures), were developed by the International Sustainability Standards Board (ISSB), which was established in 2021 under the IFRS Foundation.

Table 3. The IFRS Sustainability Disclosure Standards

Standard	Scope	Focus
<i>IFRS S1</i>	General Sustainability Disclosures	Enterprise-wide ESG-related risks and opportunities that could affect enterprise value. Covers governance, strategy, risk management, and metrics.
<i>IFRS S2</i>	Climate-related Disclosures	Specific guidance on climate risks and opportunities, including physical risks, transition risks, and climate-related financial impacts. Based on TCFD principles.

Source: IFRS.org

The IFRS S1/S2 were created to **provide investors and capital markets with reliable, comparable, and decision-useful sustainability information**. Their origin lies in:

- The need to link ESG and climate-related risks to **enterprise value**
- The growing recognition that sustainability factors materially affect financial performance
- The desire to unify fragmented global reporting frameworks into a **single, consistent, investor-focused standard**

In short, **IFRS S1/S2 makes sustainability reporting financially material and globally comparable**, bridging the gap between traditional accounting and modern ESG-driven valuation and investment decisions.

These standards aim to establish a cohesive framework for corporate reporting that integrates sustainable business practices, thereby expanding the scope of concern for intangibles beyond traditional financial accounting ([Hussinki et al., 2024](#)). As such, accounting scholars must closely monitor the evolution of the new International Sustainability Standards Board reporting standards and their profound implications for investors seeking to comprehend all value drivers and potential value destructors ([Hussinki et al., 2024](#)).

Below are the main sustainability-disclosure topics and associated metrics (codes) in the Metals & Mining industry (per IFRS S2 IBG), plus how they connect to the four pillars of IFRS S1/S2 (Governance, Strategy, Risk, Metrics & Targets).

These are drawn from the Metals & Mining (EM-MM) industry-based guidance.

Table 4. Disclosure topics and associated metrics (codes) in the Metals & Mining industry

Disclosure Topic	Key Metrics (Codes)	What / Why
Greenhouse Gas (GHG) Emissions	- EM-MM-110a.1 — Gross global Scope 1 emissions, % covered under emissions-limiting regulation- EM-MM-110a.2 — Strategy discussion (short/long term), emissions reduction targets, performance vs. targets (IFRS)	Measures direct emissions; shows how a mining company plans to reduce emissions, important for climate risk strategy and financial impact.
Energy Management	EM-MM-130a.1 — Total energy consumed; percentage grid electricity; percentage renewable (IFRS)	Captures energy usage breakdown; shows efficiency and how much energy comes from renewables, which affects operational costs and carbon risk.
Water Management	- EM-MM-140a.1 — Total fresh water withdrawn; total water consumed; % from regions with high or extremely high water stress- EM-MM-140a.2 — Number of non-compliance incidents with water quality permits or regulation (IFRS)	Vital for mining: water risk (scarcity, regulation) is high. These metrics assess water dependency, exposure, and legal / environmental risks.
Air Quality	EM-MM-120a.1 — Emissions of key air pollutants (CO, NO _x , SO _x , PM ₁₀ , Pb, Hg, VOCs) (IFRS)	Tracks polluting emissions that may have regulatory, health, and reputational costs.
Waste & Hazardous Materials Management	- EM-MM-150a.4 → EM-MM-150a.10: including total non-mineral waste, tailings produced, waste rock generated, hazardous waste generated, hazardous waste recycled, number of significant incidents, policies/procedures for waste	Very important for mining: tailings, waste rock, and hazardous materials are major environmental/financial liabilities. This set of metrics helps disclose the scale and management of these.

	management. (IFRS)	
Tailings Storage Facilities (TSF) Management	- EM-MM-540a.1 — Tailings storage facilities inventory table (e.g., number, capacity)- EM-MM-540a.2 — Corporate governance for TSF (how TSFs are monitored and managed)- EM-MM-540a.3 — Emergency Preparedness & Response Plans (EPRPs) for TSFs (SASB)	These are very specific to mining. They require disclosure about how many tailings facilities there are, how they are governed, and what plans exist in case of failure—reflecting major financial / safety risk.
Biodiversity/Land Use	EM-MM-160a.1 — Description of environmental / biodiversity policies and practices for active sites (sr2024.nornickel.com)	Mines often affect land and ecosystems; disclosure here shows how companies manage biodiversity risk, restoration, and habitat protection.
Activity Metrics	- EM-MM-000.A — Production: volumes of metal ore and finished metal products- EM-MM-000.B — Employment: total number of employees, percentage contractors (IFRS)	These aren't "risk" metrics per se, but help scale the company's operations: useful for benchmarking and normalizing other sustainability metrics.

Source: Researcher's summary

Recent developments in international reporting further reinforce TSM's relevance for valuation. The IFRS S1 and S2 Standards (IFRS Foundation, 2023) require companies to disclose material sustainability-related risks and opportunities, including climate, water, tailings, community risks, and governance issues—all areas directly addressed by TSM protocols. CPA Canada (2021) highlights that TSM data provides structured, verifiable inputs for meeting IFRS S1/S2 disclosure requirements. Because valuation is sensitive to risk disclosures, the alignment between TSM and IFRS sustainability reporting strengthens the argument that TSM indicators should be formally integrated into valuation processes.

3. Update the mining asset valuation methodology with ESG

3.1 Valuation Methods of Mining assets

Issuance of the IMVAL Code is necessary to maintain consistency, transparency, and professional integrity in mineral asset valuation. Because mining valuations guide major financial decisions—such as investment approvals, project financing, and M&A transactions—stakeholders require assurance that valuations are produced using reliable, comparable, and internationally aligned standards. The IMVAL Code provides a unified framework derived from CIMVAL, VALMIN, and SAMVAL, ensuring that competent or qualified valuers meet clear expectations for transparency, materiality, and sound methodology. (**International Mineral Valuation Committee, IMVAL, 2015**)

Ongoing verification and updates to the IMVAL Code are also essential because the mining sector evolves rapidly in terms of technical practices, reporting rules, and sustainability requirements. Emerging issues such as ESG risks, climate-related disclosures, and changes in resource classification systems must be reflected in modern valuation standards. By keeping the IMVAL Code current, the industry ensures that mineral valuations remain credible, relevant, and aligned with global regulatory and investor expectations.

Table 5. Mining assets valuation codes by Countries

Criteria	IMVAL (International Mineral Valuation Committee)	VALMIN (Australasia)	SAMVAL (South Africa)	CIMVAL (Canada)	POLVAL (Poland)	MONVAL (Mongolia) *proposal
Origin / Sponsoring Bodies	IMVAL Committee (CIM, SME, AusIMM, SAIMM cooperation)	Australasian Institute of Mining and Metallurgy (AusIMM)	South African SAMCODES Committee	Canadian Institute of Mining (CIM)	Polish Committee for Valuation of Mineral Assets	Mongolian professional institutions with regulatory support (e.g., MRAM inputs)
Geographical Scope	Global reference framework	Australia & New Zealand	South Africa	Canada	Poland/EU- oriented	Mongolia
Primary Purpose	Harmonisation of international valuation standards	Governance of public reporting of valuation and technical assessments	Valuation standards complementing SAMREC reporting	Provide transparent mineral valuation rules for public filings	Provide Polish valuation guidelines consistent with EU rules	National standard for valuation in exploration/mining licenses, feasibility, and transactions
Valuation Approaches Allowed	Income, Market, Cost (aligned globally)	Income, Market, Cost	Income, Market, Cost	Income, Market, Cost	Income, Market, Cost	Income, Market, Cost
Key Principles	Competence, Transparency, Materiality	Competence, Transparency, Materiality, Reasonableness	Competence, Transparency, Materiality	Competence, Transparency, Materiality	Competence, Consistency, Reliability	Competence, Transparency, Materiality, Cultural & local adaptation
Competent Person Requirements	Must meet IMVAL qualifications; internationally recognised	“Competent Valuer” with >5 years relevant experience	Registered Competent Valuer under SAIMM/SAMVAL	CIM Qualified Person with valuation experience	Polish- certified mineral valuers	Mongolian professional certification (subject to evolving regulatory standards)
Reporting Contexts	M&A, IPOs, disputes, transactions	Stock exchange reporting (ASX, NZX)	JSE public reporting	NI 43-101 compliance, fair market valuation	National licencing, investment, corporate transactions	Licensing, tendering, reserve estimation, investment processes
Public	Non-	Mandatory for	Mandatory under	Required for	Mandatory	Required for state

Reporting Requirements	jurisdictional but provides best practice	public filings	JSE	technical disclosures & valuation reports	under Polish legal frameworks	licensing & regulatory processes
Mining Asset Classes Covered	Exploration, development, production, closure assets	Exploration → operating mines → rehabilitation	Exploration → advanced → producing mines	Exploration, development, operating, royalty assets	Nationwide geological and mining assets	All mineral license types: exploration, reserve confirmation, mining operations
Consistency with IFRS	High (valuation principles compatible)	High (fair value principles recognised)	Moderate-High	High (works alongside NI 43-101)	Moderate (aligned with EU valuation practices)	Increasing alignment (used for state audits, asset transfers)
Treatment of Exploration Targets	Allowed with caution	Strictly regulated disclosure	Restricted, strict disclosure rules	Permitted with appropriate risk factors	Regulated	Required under Mongolian Geological Reporting Codes
Documentation Required	Full valuation report + supporting evidence	Full VALMIN-compliant report	SAMVAL-compliant valuation report	CIMVAL-compliant valuation with NI 43-101 integration	POLVAL standard technical report	MONVAL report including cadastral, geological, economic data
Ethical Rules	Avoid conflicts of interest; independence required	Strict independence and conflict-of-interest rules	Strong independence, disclosure of interests	Requires independence per CIM standards	High legal responsibility & accountability	Strong emphasis on independence due to government tendering
Recognition Internationally	High (global harmonization reference)	Very high	High (Africa)	Very high (North America)	Moderate (EU region)	Growing (Asia mining jurisdictions)

Source: Researcher's summary

Prior to the development of this international template (The IMVAL code,2015), Australasia (“The VALMIN Code, 1995”), Canada (The CIMVAL Code, 2003)” and South Africa (“The SAMVAL Code, 2016”) there was national codes. Although these codes have many similarities, they have differences in structure, definitions, scope, and jurisdictional requirements.

Other, In Poland, the Polish Code for the Valuation of Mineral Assets (“The POLVAL Code, 2008”); and In the United States of America (US) the SEC Industry Guide 7 published in 1990. Minerals while in the ground are considered as a part of Real Estate. The International Valuation Standards (IVSs) and the USA’s Uniform Standards of Professional Appraisal Practice (USPAP) also contain valuation standards of general application non-specific to mineral property valuation.

In the Mongolia, The Mongolian Institute of Geology and Mining (MGUMI) and the Mongolian Institute of Certified Valuers (MIV), an official member of the International Valuation Standards Council (IVSC), signed a Memorandum of Understanding (MoU) on February 5, 2021, to implement the Mongolian Code of Valuation of Mineral Assets.

The above codes use the same approaches as those defined in international asset valuation standards, but their application varies depending on the level of development and availability of information in each country.

The following are the commonly used approaches and methods for evaluating mining project phases. Let's compare their advantages and disadvantages:

Table 6. Relationship between mining stages and valuation approaches

Valuation approach		Market	Income	Cost
<i>Early stage exploration</i>		Not generally used	Widely used	Widely used
<i>Advanced stage exploration</i>		Less widely used	Widely used	Widely used
<i>Development properties</i>		Widely used	Less widely used	Not generally used
<i>Production properties</i>		Widely used	Quite widely used	Not generally used
<i>Dormant properties</i>	<i>Economically viable</i>	Widely used	Quite widely used	Not generally used
	<i>Economically not viable</i>	Not generally used	Widely used	Less widely used
<i>Defunct properties</i>		Not generally used	Widely used	Quite widely used
<i>Best Used For</i>		Early–mid stage assets; benchmarking	Advanced projects; producing mines	Early exploration assets with no resources
<i>Strengths</i>		Anchored in real transactions; simple	Captures economics and risk; most rigorous	Simple; useful baseline
<i>Limitations</i>		A few comparable; cyclical distortions	Highly assumption-sensitive; data-intensive	Weak link to value; ignores market and geology quality

Source: Researcher's update based on SAMVAL Code, 2016

The market approach values mineral assets by referencing prices paid in comparable transactions, public-company trading multiples, or other market-derived indicators such as \$/oz, \$/tonne, or EV/Resource ratios. This method is particularly appealing because it reflects real market behaviour and captures investors' current perceptions of risk, commodity cycles, and jurisdictional conditions. As such, the market approach offers a pragmatic and often objective

benchmark, placing it among the most useful tools for valuing early-stage exploration assets where technical and economic information is limited.

Nevertheless, the approach faces several important limitations. Mining assets are inherently heterogeneous—varying significantly in geology, grade, location, regulatory environment, and development stage—which makes finding genuinely comparable transactions challenging. Additionally, a significant portion of mining deals are private and involve complex contractual structures, such as earn-in arrangements or royalty components, which reduce transparency and complicate comparability. The approach is also highly sensitive to commodity cycle volatility; market sentiment can inflate or depress prices independently of intrinsic asset quality, potentially leading to misvaluation. For advanced development or producing assets, the market approach often lacks the granularity needed to capture site-specific risks and long-term value drivers, making it more suitable as a secondary or confirmatory valuation method rather than a standalone basis.

The income approach—most commonly implemented through discounted cash flow (DCF) analysis or real-options valuation—is widely regarded as the most rigorous and theoretically sound method for valuing mineral assets that have defined resources, mine plans, and forecastable production profiles. Its key advantage lies in its capacity to incorporate project-specific economic characteristics, including geological attributes, metallurgical recoveries, operating and capital costs, taxes, and production schedules. By explicitly accounting for the time value of money, this approach enables investors to assess both risk and long-term value creation potential. It also provides a flexible platform for integrating sustainability and ESG considerations—such as climate risk, carbon pricing, water constraints, or enhanced tailings management obligations—which can materially alter future cash flows. However, the income approach is highly sensitive to assumptions.

Small variations in commodity prices, discount rates, capital costs, or production parameters can significantly shift valuation outcomes, creating substantial uncertainty and often leading to debate among stakeholders. Forecasting long-term metal prices—sometimes over 20 to 40 years—is inherently speculative and introduces a major source of risk. Furthermore, the income approach requires detailed and reliable technical information, which is often unavailable for early-stage exploration projects.

Traditional DCF models may also undervalue optionality, such as expansion potential or exploration upside, unless supplemented by real-options analysis. Consequently, the income approach is considered most appropriate for advanced projects and producing mines where data quality and geological confidence are high.

The cost approach, which includes methods such as replacement cost and the appraised value method, is based on the principle of substitution: the value of a mineral asset is linked to the cost that a rational investor would incur to recreate it. This approach relies primarily on historical exploration and development expenditures and is commonly applied to early-stage projects lacking sufficient data for market or income-based valuation.

One of the principal advantages of the cost approach is its simplicity and transparency; it provides a clear and easily understood baseline of value and is sometimes used by regulators and auditors where more advanced techniques are not feasible. It is particularly useful when a project has no defined resource, no technical studies, and no cash-flow potential, meaning traditional methods cannot be applied. Despite these strengths, the cost approach suffers from significant conceptual limitations.

Expenditure does not necessarily correlate with economic value—many exploration programs consume substantial capital without yielding any economically viable deposit. The method also fails to reflect geological prospectivity or the probability of future discovery; two projects with identical expenditures may have very different underlying potential. Moreover, it does not account for commodity prices, market conditions, or expected cash flows, making it irrelevant for advanced projects or producing assets. As a result, the cost approach is generally considered a last-resort method and is often treated as providing only a floor value rather than a true measure of economic worth.

3.2 Valuation methods under requirements of TSM and IFRSS S1/S2

The mining industry, long associated with significant environmental, social, and governance challenges, faces increasing pressure from investors, communities, and policymakers to quantitatively monitor and enhance its sustainability performance ([Fikru et al., 2024](#)). The heightened scrutiny on sustainability has driven consolidation and standardization in reporting within the mining sector, exemplified by the European Union's adoption of the European Sustainability Reporting Standards that align with GRI and IFRS frameworks, thereby creating a unified disclosure system aimed at enhancing transparency and establishing a common language for communicating climate-related risks and opportunities, which in turn necessitates a re-evaluation of traditional mining asset valuation methodologies to effectively integrate sustainability metrics ([Yu et al., 2024](#)). Specifically, this integration requires moving beyond qualitative assessments to incorporate quantitative analyses of environmental, social, and governance factors into asset valuation models ([Bascompta et al., 2024](#)).

To this end, the following table compares how implementing TSM will affect financial performance and the valuation of mining assets.

Table 7. Financial implications of TSM

TSM Opportunity	Description	Related Financial Impact
1. Enhanced Social License to Operate (SLO)	Stronger relationships with communities and Indigenous groups; fewer disruptions	<ul style="list-style-type: none"> • Reduced probability of production stoppages • More stable cash flows • Lower operational risk premiums in discount rate (WACC)
2. Better Access to Capital	Improved ESG credibility attracts institutional investors and lenders	<ul style="list-style-type: none"> • Lower cost of capital • Access to sustainability-linked financing • Higher asset valuations due to reduced risk
3. Reduced Environmental Liabilities	Strong tailings, water, and biodiversity management	<ul style="list-style-type: none"> • Lower remediation and closure costs • Fewer fines, penalties, or accident costs • Higher long-term free cash flow
4. Improved Worker Safety and Health	Strong safety performance and transparent reporting	<ul style="list-style-type: none"> • Lower insurance premiums • Fewer work stoppages • Reduced compensation and accident-related expenditures
5. Operational Efficiency Gains	Energy and water efficiency; waste reduction; optimization processes	<ul style="list-style-type: none"> • Lower operating costs (OPEX) • Improved productivity • Increased margins and profitability
6. Competitive Market Differentiation	Preferred supplier status for responsibly sourced minerals	<ul style="list-style-type: none"> • Access to premium markets • Stronger bargaining power in offtake agreements • Long-term supply contracts with high-value clients
7. Regulatory Alignment	Alignment with global ESG regulations and GISTM	<ul style="list-style-type: none"> • Faster permitting processes • Reduced compliance uncertainty • Avoidance of project delays that erode NPV
8. Strengthened Corporate Reputation	Public and investor confidence in responsible mining practices	<ul style="list-style-type: none"> • Increased share price resilience • Reduced reputational risk costs • Improved stakeholder confidence
9. Talent Attraction and Retention	Strong safety culture and sustainability commitments	<ul style="list-style-type: none"> • Lower recruitment and training costs • Higher workforce productivity • Reduced turnover-related disruptions
10. Higher Asset Valuation and M&A Premiums	Strong TSM scores signal lower ESG-related risk	<ul style="list-style-type: none"> • Lower discount rate in DCF • Higher transaction multiples in M&A • Increased market value and investment appeal

Source: Researcher's comparison

The TSM framework, which “provides a structured set of performance indicators that strengthen accountability and sustainability outcomes in mining operations” (Côté & Kealey,

2020), enables firms to enhance their social license to operate, improve worker safety, and reduce environmental liabilities—thereby lowering disruption risks, insurance costs, and long-term remediation expenses.

Research shows that strong ESG and sustainability governance systems improve access to capital and regulatory alignment (Eccles et al., 2014; Krüger, 2015), meaning that TSM participation helps reduce the cost of capital, accelerate permitting processes, and decrease compliance uncertainty, all of which protect or increase net present value.

Consistent with findings that high ESG performance is associated with superior operational efficiency and higher firm valuation (Friede, Busch & Bassen, 2015; Broadstock et al., 2021), strong TSM results support productivity gains, talent retention, and market differentiation, ultimately contributing to higher cash-flow stability, reduced risk premiums, and increased asset valuations or M&A multiples.

The table serves as a structured tool for integrating TSM-related opportunities into financial analysis by linking sustainability performance directly to quantifiable valuation drivers. Analysts can use the table to identify which aspects of TSM influence cash-flow projections, operating and capital cost assumptions, discount-rate adjustments, reserve confidence, and long-term risk exposures.

Table 8. Impact of TSM on valuation methods

TSM Component	DCF Impact	NAV Impact	Market-Based/ Investor Impact
<i>Tailings Management</i>	Higher CAPEX/OPEX; reduces risk of catastrophic losses; may affect cash flow timing	Increases closure & remediation provisions; lowers risk of asset write-downs	Reduces reputational risk; may improve investor confidence; safer assets may trade at a premium
<i>Energy Use & GHG Emissions</i>	CAPEX for renewable energy; OPEX savings from efficiency; carbon costs included	Stranded asset risk if high-carbon projects; affects long-term reserve value	ESG-conscious investors favor low-emission operations; potential multiple premium
<i>Safety & Health</i>	OPEX for training and equipment; reduces lost-time injuries and productivity losses	Lower liability provisions; fewer operational stoppages	Enhances social licence and investor perception; lowers risk premium
<i>Water Stewardship</i>	OPEX/CAPEX for water treatment & recycling; avoids production interruptions	Increases environmental liability provisions if poorly managed	Mitigates regulatory/community risk; improves access to ESG-sensitive capital

<i>Biodiversity Conservation</i>	CAPEX/OPEX for restoration; long-term compliance costs	Increases closure/reclamation provisions	Improves public image; potential market premium for sustainably sourced minerals
<i>Indigenous & Community Relations</i>	OPEX/CAPEX for community programs; avoids project delays	Reduces risk of asset impairment due to disputes	Enhances social licence; better financing terms; reduced stakeholder litigation risk
<i>Crisis Management & Emergency Preparedness</i>	OPEX for drills and contingency systems; mitigates unexpected losses	Reduces contingent liabilities	Improves perception of operational resilience; lowers insurance cost
<i>Tailings, Waste & Closure Planning</i>	CAPEX/OPEX for progressive rehabilitation; affects terminal cash flows	Increases closure provisions; ensures compliance	Reduces post-closure liability risk; supports investor confidence
<i>Public Reporting & Transparency</i>	OPEX for verification/reporting; minimal direct cash impact	Limited direct NAV impact	Improves credibility with investors; can enhance company valuation multiples
<i>Continuous Improvement</i>	OPEX for ongoing ESG improvements; potential long-term savings	May increase CAPEX for upgrades; reduces future risk	Demonstrates proactive ESG culture; can justify higher market multiples

Source: Researcher's comparison

As emphasized by Côté and Kealey (2020), who note that “TSM provides a structured, performance-based approach that enhances risk management across mining operations,” the various TSM components—ranging from tailings and water stewardship to safety and crisis preparedness—generally increase CAPEX/OPEX but significantly reduce operational disruptions, catastrophic-loss exposure, and productivity losses, thereby stabilizing cash flows and lowering discount-rate risk premiums in DCF valuation.

Because inadequate ESG performance can elevate closure provisions, environmental liabilities, and stranded-asset risks, the adoption of TSM practices helps protect and enhance NAV by reducing the likelihood of regulatory non-compliance, project delays, and asset impairments, consistent with findings that sustainability governance improves long-term asset resilience (Eccles, Ioannou, & Serafeim, 2014).

Reflecting the broader empirical evidence that “firms with stronger ESG performance tend to earn higher valuation multiples in capital markets” (Friede, Busch, & Bassen, 2015), TSM-aligned improvements in transparency, community relations, biodiversity management, and

emissions performance enhance investor confidence, reduce perceived risk, and support premium market valuations.

By mapping each TSM opportunity to its corresponding financial impact—such as reduced operational disruptions, lower insurance and remediation costs, improved access to capital, or stronger market positioning—valuation practitioners can incorporate ESG effects systematically into DCF models, scenario analyses, and comparable transaction benchmarks.

This enables a more comprehensive assessment of asset quality, ensures that sustainability performance is reflected in financial metrics, and supports more robust, risk-adjusted valuations consistent with modern mining-industry expectations.

4. Conclusion

The integration of TSM into mining-asset valuation methodologies marks a significant shift toward incorporating sustainability performance as a core determinant of economic value. Traditional valuation approaches—such as DCF, real-options analysis, and comparable transactions—historically emphasized geological, operational, and market variables. With TSM, these models now recognize that ESG performance is not merely a reputational factor but a quantifiable driver of cost structures, risk premiums, and long-term cash-flow stability. As a result, TSM performance indicators—covering tailings governance, safety, community engagement, climate strategy, and biodiversity—become directly embedded in operational risk assessments, discount-rate adjustments, and scenario modelling.

TSM also enhances valuation precision by providing standardized, independently verified metrics that reduce information asymmetry between operators and investors. The framework enables analysts to better quantify non-financial risks such as social license to operate, regulatory exposure, and environmental liabilities, which historically were difficult to measure but increasingly influence financial outcomes. Assets with strong TSM scores demonstrate lower risk-adjusted discount rates, more resilient production assumptions, and higher expected longevity, while poorer performers face elevated risk premiums and potential impairments.

Ultimately, the reflection of TSM in valuation methodologies signals the mining industry's broader transition toward sustainability-aligned financial analysis. By systematically incorporating ESG performance into the estimation of asset value, TSM ensures that valuations reflect a more holistic understanding of long-term asset viability. This alignment strengthens investor confidence, encourages responsible mining practices, and reinforces the principle that sustainable performance is inseparable from sustainable value.

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