Effectiveness of Sustainability Disclosures in the Mining and Metals Sector – a Critical Analysis

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Abstract

Economic activity and sustainable development share a common overarching purpose: to improve quality of life. The difference lies in prioritization of stakeholders, and spatial and temporal impacts. Sustainable development explicitly incorporates welfare of all stakeholders and accounts for environmental impacts in the short and long-term while economic growth is primarily concerned with enhancing monetary value of tradeable goods and services.

The mining and metals industry plays an important role in enhancing quality of life. It enables infrastructure development and provides employment opportunities. It also has negative environmental and social impacts. It is critical to minimize them, and the first requirement is to measure them. Deteriorating ecosystems and sub-standard safety and health conditions impact local communities and employees, and to make useful choices in supporting or opposing mining activities they need to know the extent of these impacts. Investors need this information for risk assessment of their invested capital, and consumers to make choices based on their value system. This makes credible transparency important and urgent.

The purpose of this thesis was to identify the extent to which sustainability disclosures of the world's top mining and metals companies meet the needs of their stakeholders. My hypothesis was that they are currently not meeting them in a credible, relevant, and sufficient manner. Sustainability reports tend to be hyperbolic, discussing lofty future targets and expanding on a few initiatives rather than including concise and

relevant performance data. This may be done unintentionally or to distract from more important, larger issues. In addition to examining the current situation, the thesis constructed a proposal for a next-level sustainability performance dashboard for mining and metals corporations.

The research methods included developing a best practice sustainability performance reporting framework based on current commonly used frameworks and examining the extent to which the top 25 corporations (by revenue in 2020) adhere to it. The results showed that none of the corporations are obtaining a reasonable or high level of third-party assurance on the material impacts identified by them. The industry Mean Transparency Index of all sustainability categories was 59%, with a minimum of 32% for economic impacts and a maximum of 92% for female diversity. The Industry Mean Transparency Index of all companies' sustainability performance is 55% with a standard deviation of 20, and lowest and highest indices of 10% (scored by Southern Copper, USA) and 90% (scored by Newmont, USA) respectively; only 12% of relevant mining site level data was reported across the 25 companies.

Significant implications of the above findings include the low credibility of sustainability disclosures: companies have a proclivity to give disclosures that are easy to provide or make them look good, leaving out other significant topics; transparency of disclosures varies widely across companies; and local communities are not being served by the current reporting practices. To overcome these shortfalls, I provide a proposal for a next-level sustainability dashboard that could be adopted by mining and metals corporations globally, integrating simplicity, comparability, and accessibility in addition to credibility, relevance, and sufficiency of performance disclosures.

Dedication

This thesis is dedicated to all those suffering the consequences of degraded ecosystems as well as health and safety issues which have their origin in anthropogenic activities, and those working to ameliorate them.

It is also dedicated to my parents who gave me the capacity to think beyond my immediate needs.

Acknowledgments

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Table of Contents

List of Tables

List of Figures

Chapter I

Introduction

Globally, large corporations are under unprecedented scrutiny for their environmental and social impacts. Their growing influence on wealth generation and distribution can be appraised from the share of the market capitalization of the top 50 companies in the world's GDP, which has grown from 4.7% in 1990 to 27.6% in 2020 (Visual Capitalist, 2022). Large corporations are major drivers of economic activity, including employment generation, but there is also growing concern that while corporations are getting wealthier, global inequalities are increasing and the state of the world's environment is deteriorating. One of the economic sectors perceived as setting off high environmental and social impacts is mining and metals (S&P 500, 2019).

The metals and minerals extracted by the mining industry are all around us. They have been instrumental in enabling higher material quality of life that many people enjoy today and in providing employment opportunities around the world. In the foreseeable future, the energy sector's transition to renewables and energy storage technologies, essential for restricting global warming to below 2^{o} C, will sharply intensify the need for several metals and minerals (International Energy Agency, 2021).

Nonetheless, there are adverse consequences of mining. Mining and ore processing operations commonly create swathes of environmental degradation by polluting soil, water, and air in the vicinity of their sites and the energy they consume contributes to climate change. They can also create major social issues like unsafe operations, adverse impacts on health of workers, abnegation of the rights of indigenous

people and accidents from tailings dam failures (UNEP, 2020a). In short, the industry has also negatively impacted the quality of life of people and the planet's ecosystems.

A key tenet of sustainable development is sustainable and equitable management of human and natural capital resources, which corporate governance frameworks have begun to include, for example, the principle of 'do no harm' by the European Commission in 2018 (Bose, Dong, & Simpson, 2019). World over, corporate financial reporting enables owners and other stakeholders to check if management is an efficient and responsible steward of the financial capital invested; however, the existing financial accounting systems are severely limited in providing transparency on stewardship of human and natural capital, information that is important not only for owners of financial capital but all stakeholders (Bose, Dong, & Simpson, 2019). For example, natural capital around the operating sites of corporations is generally part of the economic and cultural life of local communities. Without knowing the impacts and risks of corporate activities, communities and employees are not well-positioned to take appropriate decisions for their own welfare, investors cannot conduct risk assessments, and consumers cannot make purchasing choices based on their value system. To overcome the lack of transparency on human and natural capital "corporate sustainability reporting" is being endorsed by regulators and investors, a practice which is yet evolving (Koh & Leong, 2017).

Corporate sustainability reports often run over 100 pages, contain a number of topics and information to navigate through, but lack standardized templates. This is unlike financial reports that have standard formats established, for example, income statements and balance sheets. Sustainability is a multi-dimensional topic across

economic, environmental, social impacts and governance practices, often requiring context for comprehending corporate practices and associated results. Stakeholders need to be cognizant of the company's past performance or "lagging indicators", and also the company's future plans and commitments or "leading indicators". The objective of collating all the above-mentioned perspectives in sustainability reports, with hardly any standardization, has made ESG (Environment, Social, Governance) disclosures a messy and ambiguous affair (Kell & Cort, 2021). Sustainability reporting has become an exercise in which corporations include substantial "boiler-plate language" which is largely meaningless for investors and difficult for local communities to comprehend (Cort & Esty, 2020; Böhling, Murguía, & Godfrid, 2019).

In addition to sustainability reports are a plethora of messages put forth by corporations to position themselves as sustainability leaders across public platforms, creating the perception that information on "material sustainability issues" is either incomplete or difficult to sift through as it is surrounded by extraneous noise and signaling (Cort & Esty, 2020). There are also questions on the credibility of data provided in sustainability reports as they usually come with limited or no third-party assurance (UNEP, 2020).

With widespread demand for relevant and credible sustainability reports and disclosures, the practice is ripe for evolving and improving to better serve the needs of its stakeholders and society at large. The important questions are: How effective and credible are company reports in facilitating sustainability-oriented decision-making of significant stakeholders such as investors, local communities, and customers, and how can they be made more effective?

Research Significance and Objectives

A fundamental premise of this thesis was that for sustainability reporting and ESG disclosures to be scaled up and have mainstream transformational impact they need to be comprehended by a fairly large population. Just like financial disclosures from companies drive the efficiency of financial capital, sustainability disclosures can drive the efficiency of human and natural capital. Akin to financial reports that provide a clear summary of performance in the reporting period, example profit & loss statements, sustainability reports need to include a distinct summary of "sustainability performance in the reporting period" in simpler and standardized terminology.

My research project was focused on sustainability reporting practices of corporations that carry out mining and processing operations for metals and nonmetallic minerals, and henceforth the term "mining" in this document implies mining of metals and nonmetallic minerals only, excluding mining of fossil fuels such as coal. My research evaluated the relevance, credibility, and sufficiency (as further defined in the background section below) of the current state of sustainability disclosures of large mining corporations globally for its stakeholders. I used this evaluation to extract the best practices being followed in the industry today as well as propose potential new sustainability disclosures that enhance simplicity, comparability and accessibility based on the evolving science of sustainability measurement. In addition, I proposed a "Next-level Sustainability Performance Dashboard" that could serve as a minimum but mandatory and uniform dashboard for all mining and metals corporations to include in their sustainability reports.

In contrast, it was not a goal of this research to provide frameworks for nuanced and esoteric information required for alpha isolation strategies for a narrower group of stakeholders such as investors as this would need far deeper analysis and it would be too much to expect a widely available framework to fulfil such requirements (Bose S. , 2020).

To summarize, my research objectives were:

- To identify the extent to which sustainability reports of large mining and metals corporations reveal their performance on material sustainability issues and thus meeting the needs of their stakeholders.
- To identify existing best practices in sustainability performance disclosures as well as new practices based on the evolving science of measuring sustainability, that would better facilitate informed decision making by those impacted by environmental and social externalities of the corporation.
- To propose a "Next-level Sustainability Performance Dashboard" for mining and metals corporations to be included at the start of company sustainability reports and webpages.

Background

Corporations are designed to fulfill specific mandates and agendas, most often to maximize shareholder value. As they carry out their activities certain externalities are created. Externalities refer to situations when the effect of production or consumption of goods and services imposes costs or benefits on those that are not producing or consuming them (OECD, 2021). Externalities can have positive or negative effects. Large

corporations have both. Publicizing positive externalities is an integral part of a company's efforts in building brand value, while negative externalities are often kept under wraps. This is gaining public attention now and interest in negative externalities of corporations has been growing. For society to hold corporations accountable, the first step is that their performance in all aspects is visible and accessible in the public domain. This led to the evolution of corporate sustainability reporting (Perez & Sanchez, 2009).

Reinforcing the demand for corporate transparency are international norms such as the Rio Declaration and Agenda 21 1992, that declared information on environmental impacts as internationally recognized citizens' rights (Perez & Sanchez, 2009). These call for governments and corporations to disclose information on the state of the environment and on the environmental impacts of their activities.

The State of Corporate Sustainability Reporting

By the late 1980s, calls for clear business commitments for sustainable development had emerged out of the periphery to become part of mainstream discourse. As a response, by the early 1990s a few large corporations started to voluntarily disclose related information in stand-alone environmental reports (Perez & Sanchez, 2009). Subsequently reporting on certain metrics was made mandatory by market regulators in a few countries and voluntary sustainability reporting frameworks such as the Global Reporting Initiative (GRI) and the Carbon Disclosure Project (CDP) emerged. The trend has been rising. In 2011 less than 20% of S&P 500 corporations engaged in sustainability reporting, but by 2015 the number was 81% (Koh & Leong, 2017). The practice has spread worldwide and in 2020, 80% of the top 100 from a sample of 5200 corporations across 52 countries published sustainability reports (KPMG, 2020).

However, the metrics that corporations choose to report are voluntary and the disclosures are difficult to compare, making the extraction of meaningful information from sustainability reports a challenge (Cort & Esty, 2020). The low efficacy of the practice is well explained in a publicly available letter written by the CEO of XBRL foundation, a global-standard setting organization for business performance, to the Technical Expert Group on Sustainable Finance of the European Commission in 2019, as outlined below:

- Stakeholders such as large investors when in need of comparable and meaningful information from corporation sustainability reports, purchase assessments of ESG (environmental, social, governance) credentials, risks, and opportunities from third-party service providers.
- The general practice of third-party service providers in the field of ESG assessments is to have corporations provide information as per their own specific ESG surveys, rather than relying on corporation disclosures. The information collated in these surveys is typically kept confidential and hence the veracity, consistency and utility of these survey responses can be questioned.
- As there are number of third-party service providers each corporation needs to fill out as many surveys, imposing a significant reporting burden on corporations (XBRL International, 2019).

Peer reviewed research papers and reports on the state of sustainability reporting for corporations corroborate the above inputs from XBRL International, making it clear that while reporting on sustainability performance has significantly increased in the last

decades, the quality and extent of reporting is not good enough. There are several problems and challenges. For example:

- ESG reporting standards have driven greater transparency over the years but there remains a great deal of work to undertake. Better understanding and formulation of standards for ESG data is required for decision-useful information in future disclosures. (Cort & Esty, 2020).
- ESG reporting motives are highly influenced by reporting regulations. Given the diversity in reporting regulations, comparability of ESG strategic performance is problematic (Lokuwaduge & Heenetigala, 2016).
- A study by NYU Stern Center for Business and Human Rights on Corporate Sustainability Reports states that only 8% of the over 1700 social indicators sampled reported on effects; the remaining 92% covered efforts such as policy statements and trainings provided. The study stressed the need for creators of frameworks to focus on company outcomes and impacts instead of policies and processes to enable evaluation of company performance (NYU Stern Center for Business and Human Rights, 2017).

An Overview of the Mining Sector

Metals and minerals are used in large quantities in the energy sector, and in buildings, transportation, machinery, and infrastructure projects. In addition to increasing needs from rising population and aspirations in the developing countries, a big increase in demand is anticipated from the green energy industry. Annual demand for the six major metals of iron, aluminum, copper, zinc, lead and nickel that constitute 98% of all metals

used, is estimated to increase by two to six times in the 21st century (Watari, Nansai, & Nakajima, 2021). Subsequently the demand for the mining sector to provide critical resources is only expected to rise.

Structure of the mining sector. The sector is broadly divided into large-scale mining (LSM) and artisanal and small-scale mining (ASM). It is estimated that ASM contributes about 15-20% of global non-fuel mineral production and these much smaller operations are often not in the ambit of laws and regulations (UNEP, 2020). The practice of sustainability reporting has so far been adopted mainly by companies in LSM. Large metals and mining companies are often vertically integrated, and the range of activities starting from mining and processing can extend up to global wholesaling of metals as described below (UNEP, 2013):

- Open-cut or underground extraction to bring out the ores from the ground, followed by processing or beneficiation steps such as crushing and grinding, also known as milling of the ores, to remove the non-metallic waste rock or gangue.
- Metal extraction from the ores by physically or chemically transforming them. The two main techniques are pyrometallurgy and hydrometallurgy. Pyrometallurgy involves heating of metal concentrates at high temperatures, to strip the metal from its associated mineral constituents; this process requires combusting fossil fuels for heating furnaces or electricity to power an electric arc furnace. There are several types of pyrometallurgy, and if the result is molten products the process is called smelting. Another method is using reducing agents like coke or coal to remove the impurities. Hydrometallurgy consists of treating

ores or concentrates with liquid solutions to separate metals from other mineral constituents. This is generally done by leaching, which includes dissolving the metal out of the ores by using strongly reactive solutions such as cyanide, ammonia, or sulfuric acid.

- Refining of the metal may be necessary after smelting or leaching steps, and the extent of refining will depend on the intended application. Many refining processes are electrochemical in nature requiring energy and solvents. They generally consume electricity, though diesel and other fuels may also be used.
- Casting of the metals into shapes that are easy to transport such as ingots and billets.
- Global operations for wholesaling metals to customers which will include transportation and logistics.

Figure 1 below provides a view of the metals and minerals cycle as described above. Large mining corporations often include the process up to and inclusive of smelting and refining, followed by whole-scale marketing.

Estimated quantities of metals mined globally. Metals are broadly divided into three categories: Iron and Ferro-Alloy Metals, Non-Ferrous or Industrial Metals, and Precious or Technology Metals. The base material that is mined is ores, which are naturally occurring rocks containing metals and metal alloys. Approximately three billion tons of iron ore was mined in 2019, about 98% of which was used to produce steel. Approximately 0.2 billion tons of industrial metals (e.g., aluminum, copper, manganese, lead, nickel) and 0.13 billion tons of precious metals (e.g., gold, silver, platinum) were

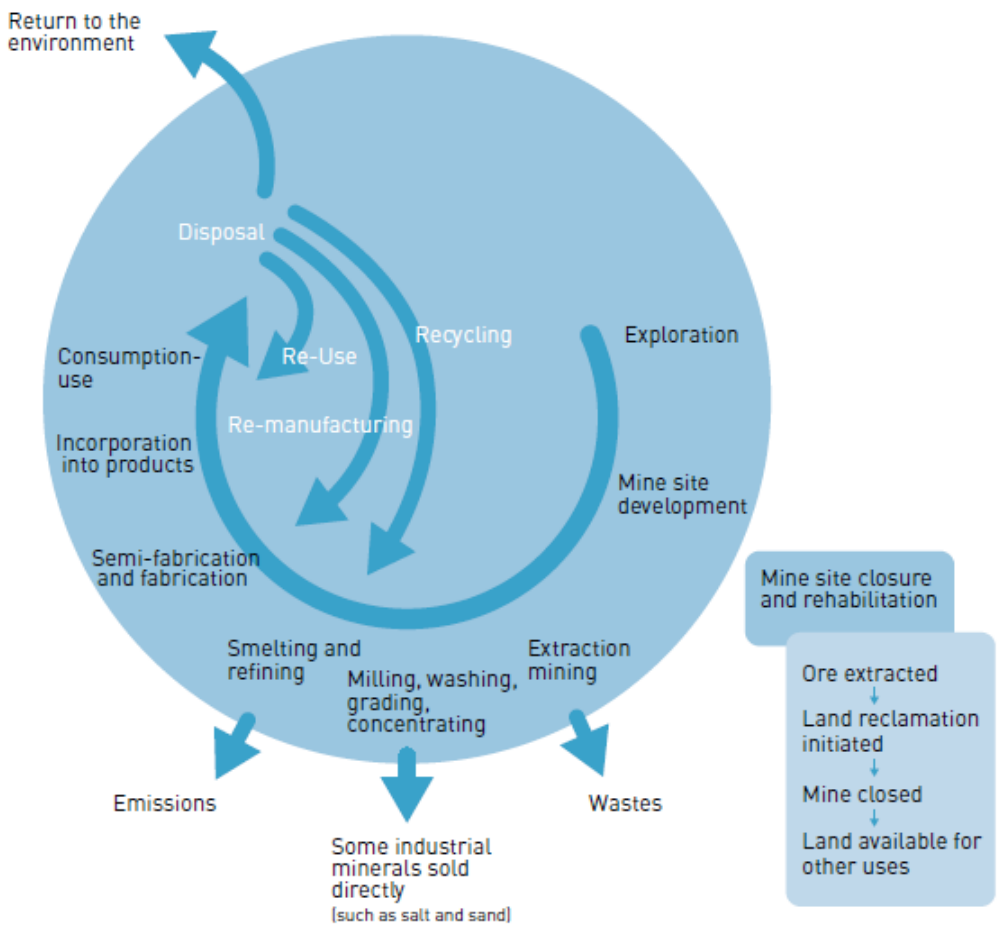

Figure 1. The Minerals Cycle.

The Mining and Metals sector starts from exploration and goes up to smelting and refining (UNEP, 2013)

mined in 2019 (Visual Capitalist, 2022). Generally, the more precious the metal, the less concentrated the ore, and greater amount of energy is required to extract the metals resulting in higher emissions to the environment. Figure 2 presents a graphical representation of the estimated total quantities of metals mined in 2019.

Figure 2. Total metals mined in 2019 (Visual Capitalist, 2022).

The State of Sustainability Reporting in the Mining Sector

Mining was one of the first industrial sectors to be put under heavy scrutiny by civil society for its significant ecological footprint and impact on communities. Noranda, a mining corporation in Canada, published its first environmental report in 1992, among the first to provide sustainability disclosures (Perez & Sanchez, 2009). In 2020 84% of the world's top 100 mining corporations published sustainability reports (KPMG, 2020).

The GRI and the Sustainability Accounting Standards Board (SASB) have recognized that different economic sectors have unique impacts and have thereby developed industry specific sustainability disclosures for the mining and metals sector.

The International Council on Mining and Metals (ICMM) is a global industry organization. Its members include 28 of the largest mining and metals companies and over 35 regional and commodities associations, representing a third of the global industry

(ICMM, 2022). ICMM has established a Sustainability Development Framework which expects all its members to publish independently verified reports on their sustainability performance using the GRI framework (ICMM, 2022).

Over a decade ago, Perez & Sanchez (2009) assessed sustainability reporting in the mining industry and reported that there had been a clear evolution in comprehensiveness and depth of information, but accessibility, third party assurance and data measurement techniques needed improvement. This remains the case.

A recent UNEP Report published in 2020 on sustainability reporting in mining argued that the practice in the sector remains immature, making the following points:

- The management of environmental and social aspects, and sustainability reporting of mining corporations, do not meet the expectations of interested stakeholders, notably communities affected by mining operations and investors.
- Only few governments have taken concrete steps to address sustainability and associated reporting in the mining sector, including South Africa and Canada. Generally, sustainability reporting of the sector falls under wider policies, including regulations that address the issue for all large or publicly listed corporations (UNEP, 2020).

Another point that has emerged is that the GRI framework for the metals and mining sector itself has several lacunae. A critique of the GRI framework by Fonseca, McAllister and Fitzpatrick makes the following point-

GRI based reports can mislead decision-makers by camouflaging unsustainable practices at the site level, while also not including legacy issues. Essentially the GRI

indicators do not appropriately provide for geographical and temporal scope. One specific example the study cites is given below:

> The following text paraphrased form BHP Billiton's report illustrates the above outcome: We own, manage or lease approximately six million hectares of land (excluding exploration and development projects). As a result of our mining, processing, smelting and petroleum activities, we have disturbed 166,000 hectares of land of which 38,500 hectares have been rehabilitated. We also manage 11,000 hectares of land for biodiversity conservation purposes. (BHP Billiton, 2009, p. 14).
>
> BHP Billiton operates in about 70 locations worldwide. The broad statements and aggregated numbers above have a limited value for biodiversity decision-making at specific sites. After all, has there been progress across all operational sites? For example, a model biodiversity program in a particular site may very well obscure biodiversity losses in different regions (Fonseca, McAllister, & Fitzpatrick, 2014).

Critics have also argued that as the disclosures are voluntary and corporations decide what is material to report, they "cherry-pick" the disclosures, manipulating the reporting process to build an image that can be misleading (Fonseca, McAllister, & Fitzpatrick, 2014). While nonfinancial disclosure may reduce public scrutiny and address legitimacy gaps, claimed sustainability does not necessarily convert into ground-level reality. Concerns have been raised that in the mining sector sustainability reporting could be used as a means to build symbolic power to deflect real issues, especially at local level (Böhling, Murguía, & Godfrid, 2019).The flagship mining case in Argentina studied by Böhling et al. (2019) suggests that the symbolic nature of sustainability reporting may create below compliance effects, avoiding clarification of negative impacts while maintaining ambiguity over their responsibility. In a study of the mining industry in Colombia, Gilbertson (2020) suggested that carbon markets and pricing institutionalized in the country became a tool for large mining corporations to build public image and profit through financialization of nature, while local communities continued to bear the

adverse impacts of mining such as serious health impacts, dispossession and water scarcity and contamination.

Type and Quality of Information in Sustainability Disclosures

Sustainability reporting primarily consists of two types of information – management disclosure that focus on how an organization manages sustainability, including strategy and approach, and topic disclosures which require past performance data or future targets in a quantitative form.

Substantial work has been done on defining data quality principles on disclosures by sustainability reporting standards such as the SASB and the GRI (Cort & Esty, 2020). A convergence is developing between them and with other organizations like the Task Force on Climate-related Financial Disclosures (TCFD) and the Sustainable Stock Exchanges Initiative that refer to the GRI principles in their guidelines. These guidelines stress the need to assess the quality of sustainability disclosures of mining corporations for relevance, credibility (audit assurance) and sufficiency on significant impacts (materiality), as described below:

1. Relevance of information: In the context of large mining corporations that have several mining sites, often spread across countries, relevance of data indicates whether it is being reported for individual mine sites or only at corporate level consolidated across units. For example, the impact of freshwater consumption will differ from site to site, depending on the water stress level of the location. These data are relevant for local communities only if it is provided at the level of individual sites.
2. Credibility of information: The sustainability reporting landscape comprises corporations that obtain no third-party assurance of their reported information, those

that obtain limited assurance, and those that obtain reasonable third-party assurance of partial or complete reports (UNEP, 2020). Higher scope and level of assurance can be considered as a proxy for data credibility.

3. Sufficiency of information on significant impacts or materiality: The concept of significant impacts or materiality for corporations in sustainability stems from the wide range of potential positive and negative impacts that corporations can have across economic, environmental, and social issues as described by standards organizations like GRI (GRI, 2016) and ISO (ISO, 2021). Every sector will have specific impacts that significantly impact people and ecosystems, while others are peripheral (Cort & Esty, 2020). As sustainability reporting is by and large a voluntary exercise, this principle assesses the extent to which the organization is reporting on its specific significant impacts.

In addition to the above principles, the following three principles of data quality should be incorporated for a "next-level sustainability performance dashboard": simplicity, accessibility, and comparability.

4. Simplicity: Only when sustainability disclosures can be understood by a critical mass of stakeholders can they influence corporation strategy and actions. This requires solving the challenge of developing disclosures that are reasonably accurate and can be represented as quantifiable data or answered with a simple yes or no.
5. Accessibility: The status today is such that many large corporations provide an overload of information on sustainability topics. However, quantity can come in the way of quality. Embedded inside hundreds of pages of sustainability reports and websites are nuggets of precious information on significant impacts that require

digging deep into long reports and separate data books, making them relatively inaccessible. My preliminary observation researching corporate sustainability reports and webpages was that the topics raised in the "Materiality" section of sustainability reports can be different from the disclosures given in the "Sustainability Performance Dashboard" in the same report. Figure 3 and Table 1 illustrate this through the example of Glencore's 2020 sustainability report – several topics that are identified as material either not included or covered meaningfully in the dashboard. (Glencore, 2021).

Figure 3. Sustainability Performance Dashboard of Glencore for 2020.

Table 1. Sustainability material topics of Glencore in 2020.

Our material topics for 2020 were:

Catastrophic Hazard Management
Catastrophic events in the natural resource sector can have disastrous impacts on workers, communities, the environment and corporate reputation, as well as a substantial financial cost. We are actively identifying, monitoring and mitigating the catastrophic hazards within our business.

Workplace Health and Safety
We prioritise the safety and health of our employees and contractors and recognise that the success of our business is dependent on a safe and healthy workforce; this is our top priority. We take a preventative approach towards health and safety to establish a proactive safety culture.

Climate Change
As one of the world's largest diversified resource companies, we have a role to play in enabling the transition to a low-carbon economy. We seek to lower the carbon footprint of our own operations, and to support national programmes to achieve the goals of the Paris Agreement.

Water
Water is an essential resource for many of our industrial activities. Some of our assets are located in areas with high and extremely high water baseline stress and share access to water with other local water users. Our assets undertake detailed assessments of their local environmental conditions during the operational changes in their life cycle, to develop water management strategies that maximise the efficient and sustainable use of this important natural resource.

Land Stewardship
Our assets around the world have direct and indirect impacts on the land. From project design to operational closure, we focus on reducing our physical footprint on the land, identifying, managing and addressing our potential impacts by applying the principles of the mitigation hierarchy (avoid, minimise, restore/mitigate and offset). We look for ways to improve our land stewardship, reduce our impact on landscapes and enable sustainable land use following the closure of our operations.

Human Rights
We recognise we have the potential to impact human rights directly through our operations, and indirectly through our relationships with joint ventures, contractors and suppliers. We are committed to respecting human rights and actively support our workforce, business partners and suppliers to understand and meet this commitment.

This year, we have included our previous standalone Human Rights Report in this Report.

Responsible Citizenship
Mining activities can make a significant contribution to the national, regional and local economies in which they operate, through employment, tax and royalty payments, local procurement and social development. Our aim is to minimise adverse impacts from our activities and to build partnerships to support sustainable development and growth.

Responsible Sourcing and Supply
We seek to incorporate social, ethical and environmental considerations in our relationships with suppliers and customers. In particular, we are committed to understanding and addressing the risk of human rights violations in our supply chains.

Our People
Attracting and retaining entrepreneurial, focused and dedicated people is fundamental to our future success. We thrive by having a workforce from different backgrounds, cultures and beliefs. This diversity brings the new ideas, innovation and different ways of working that are a core part of who we are at Glencore.

The above topics have not been integrated in the company's sustainability dashboard shown in Figure 3

6. Comparability: Corporations provide the world with products and services that are widely used. In this process they use natural capital, but like financial markets that reward corporations for efficient use of financial capital, there is no system to reward those that use natural capital efficiently. A major reason why financial disclosures are comparable across companies is the availability of financial data scaled in terms of the magnitude of business activity. For example, profitability can be expressed as a percentage of revenue, and return as a percentage of capital investment. This

facilitates comparing the performance of corporations for efficiency in utilization of capital. In the case of sustainability metrics, with the exception of a few indicators like total injury frequency rate per million hours, there are very few metrics reported in terms of business intensity. Making sustainability disclosures available in terms of business intensity will facilitate the role of a competitive "market" in rewarding high performers and penalizing the laggards.

Research Questions, Hypotheses and Specific Aims

My research questions focused on assessing and comparing sustainability topic disclosures of large mining and metals corporations. These disclosures do not require descriptive text explaining management strategy, but performance indicators that can be expressed quantitatively or answered with a yes or no. By no means have I assumed that management disclosures are less significant than topic disclosures; however, I believe they serve a different purpose and should be elaborated separately.

Answering the research questions and evaluating the hypotheses below required development of a "best practice sustainability performance framework" that covers relevant disclosures from reporting frameworks in use today, such as GRI, SASB and ICMM as well as current best practices of 25 of the largest mining corporations. I examined the following research questions and hypotheses using the above framework as the benchmark:

Are large mining corporations providing relevant, credible, and sufficient information on the significant impacts that are created from their operations? Alternatively, do their sustainability reporting practices reveal sufficient information

needed by stakeholders to evaluate the negative externalities of mining and ore processing activities?

I hypothesized that the 25 corporations in my research sample of the industry do not provide reasonable credibility and do not reveal relevant and sufficient information needed by stakeholders to evaluate the negative externalities created from their operations in their sustainability reports. To prove or disprove this hypothesis I examined the following sub-hypotheses:

H1: Less than 10% of the corporations adhere to the industry best practice of providing third party reasonable / high assurance on the material parameters they identified in their sustainability reports.

H2: The industry Mean Transparency Index of all sustainability categories (MTI_{SC}) is less than 50%.

H3: The industry Mean Transparency Index of all companies' sustainability performance (MTI_{CSP}) is less than 50%. The difference in the evaluation of MTI_{CSP} and MTI_{SC} is that MTI_{CSP} incorporates subjective weights to the sustainability categories based on their perceived significance while MTI_{SC} does not.

H4: Less than 20% of relevant mine site-level sustainability performance disclosures are provided across the industry.

Specific Aims

To complete my research, I:

1. Developed a baseline framework that was materially significant for sustainability performance metrics for the mining and metals sector and that could be quantified or answered with a yes or no.

2. Analyzed the sustainability disclosures of the top 25 mining and metals corporations globally based on the framework developed and that evaluated the hypothesis described above.
3. Identified best practices in sustainability reporting in the sector from the 25 corporations analyzed from previous literature and industry reports; evaluated potential new practices that could enhance the effectiveness of sustainability disclosures.
4. Constructed and proposed a next-level sustainability performance dashboard with topic disclosures for the mining and metals sector, to be used at the start of sustainability reports or in the highlights section of their webpages as a standardized high-level summary of their sustainability performance.

Chapter II

Methods

The research design comprised gleaning out a set of sustainability performance disclosures that a mining and metals corporation should provide to satisfactorily cover material sustainability issues from the vast number of existing disclosures currently deployed in the GRI, SASB and ICMM frameworks and corporate sustainability reports. This enabled development of a potential best practice performance framework that covers a company's sustainability performance in the reporting period and can be quantified or answered with a yes or no. This was followed by analysis of disclosures provided by the top 25 corporations for relevance, credibility, and sufficiency of information with the developed framework as the benchmark. The final step was construction of a proposed next level sustainability performance dashboard incorporating some of the current best practices and some new metrics to enhance simplicity, comparability, and accessibility of sustainability disclosures in addition to relevance, credibility, and sufficiency.

Please refer to the background section for definitions of relevance, credibility, sufficiency, simplicity, accessibility, and comparability of information for the purpose of this proposal.

Developing a Sustainability Reporting Framework

To develop the best practice sustainability reporting framework based on current practices, I started with identifying significant impacts of the mining and metals industry. I reviewed the literature on social and environmental externalities of the mining industry

as well as reports from industry associations and civil society to deepen my knowledge of the most significant issues. I examined sustainability reports of a sample of mining corporations and existing reporting frameworks of GRI and SASB. As per the UNEP report on sustainability reporting in the mining sector (UNEP, 2020) and as per my own observations, it is evident that many corporations report only consolidated disclosures at the corporate level, with few providing certain disclosures at mining site level. It is widely accepted that certain disclosures are required at both levels to serve the information needs of all stakeholders (ICMM, 2021; UNEP, 2020).

Steps for Developing Transparency Indices and Checking Hypotheses

The steps for developing transparency indices comprised:

1. Identification of the top 25 mining corporations globally, based on their annual revenue in 2020. Sources of information included stock market indices, industry reports and corporation websites.
2. Appraisal of information available within sustainability reports and company websites on the level and scope of third-party assurance of their sustainability disclosures. This helped examine hypothesis H1.
3. Appraisal of disclosures provided in the sustainability reports and company websites for whether the identified metrics for each of the sustainability categories included in the best practices framework have been reported.
4. Evaluation of Industry Mean Transparency Index of all Sustainability Categories (MTI_{SC}) to check for hypothesis H2 by:

- Allocation to each company a maximum score of 1 for each sustainability category included in the framework. The score of 1 was divided equally across the metrics included within the category.
- Transparency scoring of every sustainability category based on information provided or not provided for each of the category metrics by all the corporations. For example, if one category disclosure has four metrics, a score of 0.25 was given for the metrics for that disclosure. To reiterate, scoring was done only based on whether the company provides the specific disclosure or not.
- The Mean Transparency Index of each Sustainability Category (MTI_{SC}^{n}) was calculated by dividing the sum of the score of all the 25 companies by the maximum possible total for the specific category and the ratio converted into a percentage value. The industry Mean Transparency Index of all sustainability categories (MTI_{SC}) is the mean of the indices across the categories. The mathematical formulas are:
    - $MTI_{SC} = \sum_{\text{sustainability categories}} MTI_{SC}^{n} / N$
    - $MTI_{SC}^{n} = \sum_{\text{companies}} CTI_{m}^{n} / M$
    - MTI_{SC} = Industry Mean Transparency Index of all sustainability categories
    - MTI_{SC}^{n} = Industry Mean Transparency Index of one sustainability category
    - CTI_{m}^{n} = Transparency Index of company *m* for sustainability category *n*, where

- *n* represents any single sustainability category from N total categories identified as significant for the mining and metals industry
- *m* represents any single company from M total companies included in this study
- *N* represents the total number of sustainability categories
- *M* represents the total number of companies

5. The steps below were followed to obtain the Industry Mean Transparency Index of all companies' sustainability performance (MTI_{CSP}) to test hypothesis H3:
   - Weightages were allocated to each sustainability topic based on a subjective assessment of its perceived significance.
   - The transparency score of each sustainability topic for each company was adjusted for its assigned weightages and the scores across categories summed up for each company. The Transparency Index of each company's sustainability performance (CTI_m) was obtained by dividing the company's total score across categories with the maximum possible score and the ratio converted into a percentage.
   - The Industry Mean Transparency Index of all companies' sustainability performance (MTI_{CSP}) was obtained by calculating the mean of the Transparency Index of the individual companies (CTI_m). The mathematical formulas are:
     - $MTI_{CSP} = \sum_{Companies} CTI_m / M$
     - $CTI_m = \sum_{sustainability\ categories} W_n\ CTI_m^n / N$
     - MTI_{CSP} = Industry Mean Transparency Index of all companies' sustainability performance

- CTI_m = Company Transparency Index across all sustainability categories
- CTI_m^n = Transparency Index of Company *m* for sustainability category *n*
- *n* represents any single sustainability category from N total categories identified as significant for the mining and metals industry
- *m* represents any single company from a M total companies included in this study
- *N* represents the total no. of sustainability categories
- *M* represents the total no. of companies
- W_n = Weight of sustainability category *n* in overall company transparency index

A point worth highlighting is that mathematically the only difference between MTI_{CSP} of MTI_{SC} is that evaluation of MTI_{CSP} incorporates subjective weights to the sustainability categories based on their perceived significance while MTI_{SC} does not.

6. The steps below have been followed to check for the extent of data provided at the level of mining sites and check for hypothesis H4:
   - The scores received by all 25 corporates for the metrics identified specifically and only for site level data under each sustainability category were summed up. This total was divided by the maximum possible score for site level disclosures across companies and the ratio converted into a percentage.

Steps for Developing the Proposed Next-Level Sustainability Performance Dashboard

The steps for developing a sustainability performance dashboard comprised:

1. Identification of best practices in sustainability reporting in the mining and metals from the reporting frameworks in use today, the reports of the 25 corporations and the evolving science of sustainability measurement.
2. Development of the proposed next level dashboard by refining and improving the framework developed in the first step, based on new insights from the research and analysis carried out. This required strengthening and incorporating the six principles: of relevance, credibility, sufficient information on significant impacts, and simplicity, accessibility, and comparability between companies as defined in the background section.

Chapter III

Results

The results evaluate the sustainability disclosures of 25 of the world's largest mining companies by revenue in comparison to a Best Practice Sustainability Performance Framework and propose a Next-level Sustainability Performance Dashboard.

The Best Practice Sustainability Performance Framework

An extractive industry like mining of metals implies utilizing the natural resources found within the earth. This leads to questions of ownership and fair distribution of the wealth generated. Other major issues include the health and safety of workers in the mining sites, local communities, and surrounding ecosystems as well as issues around human rights and the rights of indigenous people among others.

The best practice sustainability performance framework to evaluate and compare reporting practices of mining and metals corporations was developed based on the most significant impacts of the industry and the related sustainability performance metrics from the commonly used frameworks today: GRI topic disclosures (Global Reporting Initiative, 2022); GRI G4 Sector Disclosures for Mining and Metals (Global Reporting Initiative, 2013); SASB for the metals and mining sector (SASB, 2018) and ICMM member requirements (ICMM, 2022); as well as the current reporting practices of the 25 largest companies. In addition to the above, the following UNEP reports and journal papers were consulted to identify and summarize the significant sustainability impacts of

the mining and metals industry: Environmental Risks and Challenges of Anthropogenic Metal Flows and Cycles (UNEP, 2013); Mineral Resource Governance in the 21st Century (UNEP, 2020); Sustainability Reporting in the Mining Sector - Current Status and Future Trends (UNEP, 2020a); Catastrophic Failures Raise Alarm about Dams Containing Muddy Mine Wastes (Cornwall, 2020); Sustainability Reporting Among Mining Corporations: a Constructive Critique of the GRI Approach (Fonseca, McAllister, & Fitzpatrick, 2014); and Sustainability Reporting in the Mining Sector: Exploring Its Symbolic Nature (Böhling, Murguía, & Godfrid, 2019). The findings on the mining and metals sector's most significant sustainability impacts and the related performance metrics commonly used today are organized under the numbered topics below.

1. Economic Impacts

The aim of any economic activity including mining and production of metals is wealth generation and enhanced quality of life. However, in resource-rich developing countries, often mining activities do not translate into broad-based economic, human, and social development. This particularly happens when the industry develops in an "enclave", with only few links to the local economy. Additionally, disruption of ecosystems and social fabric can lead to deterioration of governance and serious conflicts. Based on this, the most relevant available metrics for evaluating a company's economic performance are:

a. GRI Disclosure 201-1 Direct economic value generated and distributed (EVG&D). This provides an indication of how the wealth generated by the organization is divided across its stakeholders, that is capital providers, employees, suppliers, governments, and local communities. For a multinational

enterprise, significant stakeholder value lies within the country-by-country break-up of this information. On this aspect GRI instructions states the following – "Where significant, report EVG&D separately at country, regional, or market levels, and the criteria used for defining significance" (Global Reporting Initiative, 2022). In my view this discretion should not lie with the organization, but rather country-by-country reporting of EVG&D should be mandatory for all corporations operating in more than one country.

b. Another disclosure that aligns only with country-by-country tax reporting is Disclosure 207-4 from GRI 207: Tax 2019. This is aligned with ICMM Principle 10 of Stakeholder Engagement, Performance expectation 10.2 which requires publicly supporting the Extractive Industries Transparency Initiative (EITI) and transparency of material payments to governments. If EVG&D is not given country-by-country this would be the next best metric for economic impacts.

c. The only disclosure that SASB offers on the topic of business ethics and transparency is: "Production in countries that have the 20 lowest rankings in Transparency International's Corruption Perception Index". This has only limited value for capital providers and no value for local stakeholders.

2. Greenhouse Gas (GHG) Emissions

The mining and refining of metals are highly energy intensive activities, consuming about 8% of the global energy produced (UNEP, 2013). This includes direct use of fuels, such as combustion of coal to produce heat, or the use of electricity, which is largely produced through fossil fuel combustion. The relevant available metrics for this are:

a. The SASB metric of percentage of total energy used within the organization from renewable sources as part of SASB EM-MM-130a.1. This is also available within the details of GRI Disclosure 302-1 Energy consumption within the organization. This is among the best disclosures for comparing companies on their commitment to climate change. However, this accounts only for energy consumption inside the organization, and inefficiencies in energy management in the upstream and outsourced activities of the company are not accounted for. GRI Disclosure 302-2 Energy consumption outside of the organization could cover this gap but this is hard to report and consequently not commonly used.
b. The GRI Disclosure 305-1 Direct (Scope 1) GHG emissions and Disclosure 305-2 Energy indirect (Scope 2) GHG emissions are significant from the perspective of evaluating the GHG emissions trend of the organization over time and whether it is on its declared pathway of reducing GHG emissions, if any. Both these disclosures also cover emissions only from activities within the organizations. GRI Disclosure 305-3 Other indirect (Scope 3) GHG emissions aims to cover the emissions outside the organization's core activities but with several categories included in this, there is no consistency in its reporting across organizations, making the information unmeaningful.
c. GRI Disclosure 305-4 GHG emissions intensity is an organization specific indicator, providing the emission intensity ratio of the organization in which the denominator is decided by the organization, for e.g., tonnes of GHG emissions per tonne of copper produced. The numerator can be Scope 1, Scope 2 or/and Scope 3 GHG emissions of the organization. This could be a valuable metric to compare

carbon emissions per tonne of metal produced across companies. Many companies report this with the combined Scope 1 and Scope 2 emissions in the numerator and metal produced or ore mined in the denominator. Nevertheless, gaps remain as Scope 3 or value chain emissions are not included and the emission efficiency of companies with different operating models cannot be compared. There are very few companies with comparable metals or mineral mixes in their product lines.

d. With respect to GHG emissions, the only metrics included by SASB is Scope 1 emissions which is already covered above.

3. Waste and Tailings Management

The mining process excavates large quantities of ores or rock from the ground. The rock which gets extracted during the mining process but does not have any economic value is known as waste rock, a prominent cause of altered landscapes around mining sites. It is estimated that globally waste rock generated from mining of iron ore is in the order of one billion tonnes annually. The other major mining waste is tailings, these comprise finally crushed and processed ore saturated with water from which the metals of economic value have been extracted. They can be highly acidic and are normally discharged by slurry pipelines into engineered impoundments known as tailings dams or tailings storage facilities (TSF), which can cover tens of square kilometers. Associated risks include seepage of acidic waters from their base and accidental collapse of dams, causing human fatalities and destruction of the surrounding ecosystem. The waste rock and tailings waste are together known as mineral waste; for large mining companies these are in the order of millions of tonnes annually. The third type of waste is the one

produced from non-mining operations of the company, for example, office and canteen waste. It is known as non-mineral waste and is in the order of thousands of tons annually. The first and largest impact of tailings facilities and solid waste generated is on local communities and ecosystems. It is therefore important to have site-by-site break-up of the waste generated. The relevant available metrics for this are:

a. The GRI disclosures on waste generated and accidental spills: 306-3 Total weight of waste generated in the year, breakdown by composition; 306-4 Waste diverted from disposal and Sector Specific disclosure G4-MM3 Total number and volume of significant spills and environmental incidents. SASB disclosures EM-MM-150a.1 Total weight of tailings waste, percentage recycled and EM-MM-150a.2 Total weight of mineral waste, percentage recycled are equally suitable for understanding the total scope of mineral and tailings waste generated and recycled. Neither GRI nor SASB ask for site-by-site details of waste.
b. Tailings Storage Facilities (TSFs) Disclosure: In 2019 investors representing the Church of England Pensions Board and the Council on Ethics Swedish National Pension Funds (The Church of England, 2022) estimated that there are about 18,000 TSFs across the world of which 3500 are active. At an estimated failure rate of 1.2%, three of the world's 3500 major tailing dams fail each year (Lyu et al, 2019). In this century alone 11 of these failures have been catastrophic causing major social and environmental damage and the frequency of such failures is expected to rise in the near future (Lempriere, 2019). As no public record of the scale or risks levels of TSFs was available the above-mentioned fund managers contacted about 700 mining companies provide these on a defined template. This

included relevant parameters like volume of tailings, area occupied, height, risk levels and assessment schedules for each TSF. As of May 2021, 44 of the largest 50 companies had provided the data site by site, freely accessible online (The Church of England, 2022).

c. Publicly announced alignment with Global Industry Standard on Tailings Management guidelines as per ICMM conformance protocol. On 25 January 2019, the collapse of a tailings storage facility at Vale's Córrego de Feijão mine in Brumadinho, Brazil led to the death of 270 people. and poured 12 million cubic meters of mud and sludge into the local environment up to five miles downstream (Cornwall, 2020; Lempriere, 2019). This was a decisive moment in the mining industry, leading to wide scale demand for radically improving the safety standards of TSFs worldwide. The International Council on Mining and Metals (ICMM), the United Nations Environment Program (UNEP) and the Principles for Responsible Investment (PRI) co-convened to establish an international standard, resulting in the launch of the Global Industry Standard on Tailings Management in August 2020 (Global Tailings Review, 2022). ICMM members have a conformance commitment with the standard for all their facilities with 'extreme' or 'very high' potential consequences by August 2023 and all other facilities by August 2025 (ICMM, 2022)

4. Land

Mining activities lead to major disturbances to the land. Problems arise as ecosystems do not work in isolation, and when large tracts of land are disturbed, the surrounding land is impacted as well e.g., disturbances in water drainage patterns, rising

dust levels and seepage of toxins. This leads to deterioration of the quality of surrounding land for agriculture and other purposes, adversely impacting local communities. Mine closure generally takes place when all the ore that can be extracted with net positive economic value is finished. At this point the land needs to be reclaimed so that it can be put to other uses, and more importantly the corporation needs to ensure that there is no chance of toxic emissions leaching into the surrounding ecosystems once the mining site is closed. For example, across the world there are several former mine sites which closed long back but are still leaching AMD (Acid Mine Drainage) into surrounding surface waters or infiltrating into groundwater.

a. The best available metrics for this currently is GRI Sector Specific disclosure G4-MM1 on Land Total amount of land newly disturbed within the reporting period, Total amount of land newly rehabilitated within the reporting period to the agreed end use; and Total land disturbed and not yet rehabilitated. SASB does not have a disclosure on Land disturbed and rehabilitated.
b. GRI does not have a disclosure on AMD leaching while SASB does. However, it is not commonly used and therefore not included in the best practice framework.

5. Water

Mining and metals production can significantly impact the quantity and quality of surface and ground water available in the surrounding areas. The process of mineral processing and dust suppression requires large amounts of water in the order of gigalitres (GL) per year for large scale operations. Run-offs of contaminated water, seepage from retention ponds, tailings dams and mineral wastes creating toxicity in the water of the surrounding ecosystems is not uncommon. This is directly harmful to the health of

humans and all other lifeforms. If there are sulfidic minerals contained in the ore and/or waste rock, sulfuric acid will be formed with exposure to water and oxygen, leaching out numerous metals and salts. This is commonly known as acid mine drainage or AMD which is acutely toxic to aquatic ecosystems. The distribution of water around the world is not uniform and the classification of locations based on baseline water stress levels is available e.g., by the World Resources Institute's (WRI) Water Risk Atlas tool, Aqueduct. (World Resource Institute, 2022). As the first and largest impact of water used by any entity will be on local communities, it is important to have these data by mining site. The relevant metrics are:

a. GRI 303-5 Total water consumption from all areas including percentage from high and extremely high-water stress areas; the related SASB metrics for fresh water are included in EM-MM-140a.1. With respect to water consumption data by site, GRI 303-5 recommends giving consumption data by site in high-water stress regions. SASB does not mention giving the data by site.
b. The SASB metrics EM-MM-140a.2 Number of incidents of non-compliance associated with water quality permits, standards, and regulations.
c. Percentage of water recycled is a significant indicator of efficiency in water used. This is given by several companies but is not a metrics in the GRI or SASB frameworks.

6. Air Quality

The toxicity of air in the local areas can be significantly impacted from smelter stack gas emissions that contain particulate matter with metals such as arsenic, copper, cadmium, antimony, zinc, chromium, lead and selenium, impacting human health. Sulfur

dioxide has also been a common emission of concern from the smelting of metal sulfide concentrates. It reacts with atmospheric water vapor to form sulfuric acid or “acid rain” which can harm existing vegetation and prevents new vegetation from growing due to acidic conditions of the soil. The relevant metrics for this are:

a. GRI metrics 305-7 and SASB EM-MM-120a.1, both of which ask for disclosures on total air pollution with a break-down by type of pollutants.
b. Data on site level pollution with a breakdown by pollutants would be far more important for local communities. GRI 305-7 recommends providing data by facility ‘where it aids transparency or comparability over time’. SASB does not mention it.

7. Biodiversity

The mining and minerals sector generally does not occupy more than 1% of a country’s area and is usually not the most important influence on biodiversity in a particular region. However, we need to be cognizant that removal of vegetation and altering the landscape of large tracts of contiguous land will negatively impact species due to decrease in the availability of food and shelter – small and large forms. There is also the possibility of a major impact on the aquatic life forms in the surrounding waterways due to rising levels of acidity and sediments. While GRI and SASB do have some metrics for this they are not simple and comparable, therefore do not provide value in a high-level reporting framework. The best indicator for this would be land disturbed, which is already included in land impacts category above.

8. Safety and Health of Workers

There has been substantial improvement in the working conditions of workers in mines in the last decades, but fatalities and injuries of workers in the mining sector remain high, emanating mainly from heavy machinery, shaft and slope collapses, water invasions and specifically in underground mines methane leaks. Incidents of occupational diseases occur due to physical conditions as well as exposure to hazardous substances examples of which include musculoskeletal disorders, noise-induced hearing loss, skin disorders and acute pneumonia amongst others. The relevant high-level metrics for this are:

a. GRI metrics 403-9 that include Fatalities in the year, Fatality rate in the year, TRIFR (total recordable injury frequency rate) and Occupational disease frequency rate. The related SASB metrics EM-MM-320a.1 includes the MSHA all-incidence rate and fatality rate.

9. Human Rights and Rights of Indigenous Peoples–

Mineral deposits are often located in lands that are closely connected with indigenous people. Any activity carried out in these lands without their prior and informed consent is an abnegation of their rights. Another issue is maintaining security of mining operations and related cases of human rights abuses by the security staff. GRI and SASB do include some metrics on these, but currently corporate sustainability reports rarely include these topics. Such information is better collected from third-party sources, for example, reports of international non-governmental organizations like the Transition Minerals Tracker (Business and Human Rights Resource Center, n.d.) and media outlets.

10. Workforce Relations and Diversity

Worker rights are considered a significant issue in the extractive industry. Issues include restriction of civil liberties and the right to freedom of association and collective bargaining. Instances of clashes between labor and management are not uncommon. In addition, the mining sector is also known to be traditionally male dominated. A focus on gender diversity and equality would be beneficial for national economies and communities. The relevant metrics for the above aspects are-

a. GRI 102-41 and SASB EM-MM-310a.1 for percentage of workers covered under collective bargaining agreements
b. G4-MM4 GRI Sector specific disclosure and SASB EM-MM-310a.2 for number and duration of strikes and lockouts in the reporting period
c. GRI disclosure 403-9 for percentage of women in total workforce.

11. Credibility of Sustainability Reports and Disclosures

An indication of the credibility of a corporation's sustainability disclosures is the level of third-party assurance of parts of or the complete reports. The two commonly used standards for this are ISAE 3000, which provides the options for limited and reasonable assurance levels and AA1000AS, which provides the options for moderate and high assurance levels (Rao, 2017). ICMM has developed an Assurance and Validation procedure that members are required to adhere to. It includes annual assurance of the corporation's sustainability performance against the Global Reporting Initiative (GRI) Sustainability Reporting Standards (minimum Core option) by independent third-party qualified validation service providers using a recognized assurance standard (ICMM, 2022).

The Best Practice Sustainability Performance Framework and Evaluation Model

Table 2 summarizes the most relevant disclosures discussed above, a few of which are best practices that are not present in the GRI or SASB frameworks but are already being deployed by at least one company. The disclosures under the 11 categories constitute the best practice performance framework for this thesis, constructed with the objective of evaluating industry transparency of sustainability performance and considering the reporting maturity and quality of the disclosures themselves.

We need to bear in mind that the best practice framework provides an indication of sustainability performance from one source only, that is the corporates themselves. My research of the reporting practices of the 25 companies showed that for several social, integrity and ethics metrics included in the GRI framework, disclosures are scarce and thus of very limited value. For example, for GRI 205 -1 and GRI 206-1a, which are disclosures for "confirmed incidents of corruption" and "number of legal actions pending or completed on anti-competitive behavior and violations of anti-trust and monopoly legislation" respectively, very few corporations report anything at all, citing privacy and legal reasons. No worthwhile sustainability evaluation can be based only on disclosures provided by corporates themselves. For issues such as human rights, integrity and ethics, information should be collated from other sources such as civil society, non-governmental organizations, and media.

The relative weightage of each category in Table 2 is shown in Figure 4 based on their perceived significance to the stakeholders. The 11 topics in the table are grouped under four major themes: Economic Performance, Environmental Performance, Social Performance and Credibility.

Table 2. Best-practice sustainability performance framework.

No.	Categories and metrics	GRI / SASB / ICMM disclosures and requirements
1.	Economic impacts	
a.	Economic Value Generated & Distributed- Country by Country	GRI 202-1 guidance: Country-by-country if relevant
b.	Tax – Country by Country	GRI-207-4; ICMM P.E.10.2 for publicly supporting EITI (Extractive Industries Transparency Initiative)
2.	Greenhouse Gas (GHG) emissions	
a.	% Renewable energy in total energy mix	SASB part of EM-MM-130a.1; GRI Part of 302-1
b.	GHG Scope 1+2 Emissions	GRI 305-1, 305-2; SASB EM-MM-110a.1- Scope 1 only
3.	Air Pollution	
a.	Total Air Pollution – breakup by pollutants	GRI 305-7; SASB EM-MM-120a.1
b.	Air Pollution – breakup by pollutants, by site	GRI 305-7 guidance: site level data if considered relevant
4.	Water	
a.	Total water consumed	GRI 303-5. SASB EM-MM-140a.1- specifies freshwater
b.	% From high or extremely high-water stress areas	GRI 303-5. SASB EM-MM-140a.1
c.	Water consumption by site	GRI 303-5 Recommendation to give consumption data by sites in high-water stress regions
d.	No. of water related incidents of non-compliance	SASB EM-MM-140a.2
e.	% Of water recycled	-
5.	Solid waste	
a.	Total mineral waste generated; % mineral waste diverted from disposal / Recycled	GRI 306-3, 306-4, SASB EM-MM-150a.1 & EM-MM-150a.2
b.	Total no. & volume (m3) of significant spills	G4-EN24 – GRI Sector Specific disclosure
c.	Waste data by site	-
6.	Tailings Management	
a.	Site-wise tailings data e.g., aligned with Church of England disclosure requirements	-
b.	Publicly announced alignment with GISTM guidelines as per ICMM deadline	ICMM member requirement
7.	Land and biodiversity impacts	
a.	Total land disturbed and not rehabilitated at end of 2020 (Ha)	G4 MM1
b.	Total land disturbed and rehabilitated in 2020 (Ha)	G4 MM1
c.	Land data by site	-
8.	Workforce relations	
a.	% Of workers covered under collective bargaining agreements	GRI 102-41; SASB EM-MM-310a.1
b.	Number and duration of strikes and lockouts	G4-MM4 GRI Sector specific disclosure; SASB EM-MM-310a.2
9.	Health & Safety of workers	
a.	Fatalities in the year	GRI 403-9
b.	TRIFR (total recordable injury frequency rate)	GRI 403-9; SASB EM-MM-320a.1
c.	Occupational disease frequency rate	GRI 403-9

No.	Categories and metrics	GRI / SASB / ICMM disclosures and requirements
10.	Female diversity	
a.	% Of Women in total workforce	GRI 405-1
11.	Credibility of sustainability reports	
a.	Level of third-party assurance of sustainability reports	Standard industry best practice and ICMM member requirement

ICMM requires reporting in alignment with GRI core reporting standards. References to the GRI, SASB and ICMM framework requirements mentioned in the table are provided in the text content above the table.

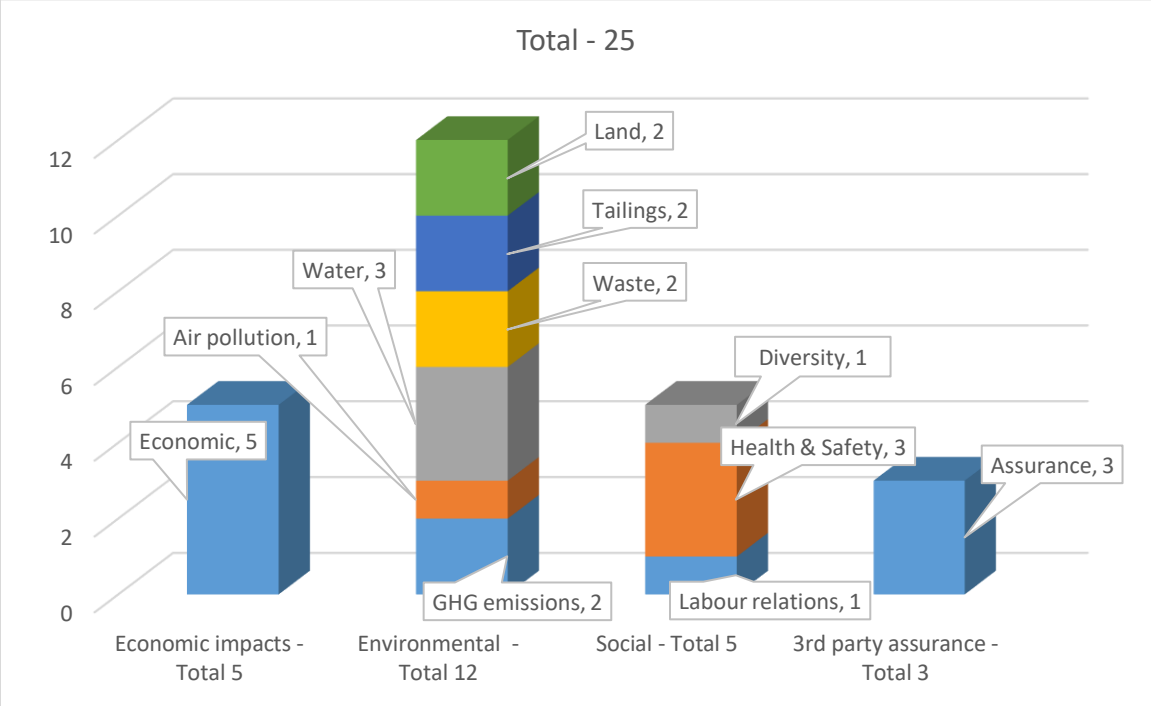

Figure 4. Category weightage model for transparency indices.

The figure illustrates how a total score of 25 has been divided across sustainability categories based on subjective perceived significance to evaluate Mean Transparency Index of company sustainability performance (MTI_{CSP})

Evaluating Current Reporting Practices of Top 25 Corporations

The top 25 metals and mining corporations based on their 2020 revenues, and used as the sample for this research, are listed in Table 3. Evaluation of sustainability

disclosures of these companies extracted from their sustainability reports, ESG data books, websites and annual reports show a wide variation in the extent of disclosures provided.

Table 3. Top 25 mining corporations by revenue, 2020.

No.	Company	Country of Headquarters	Revenue 2020 (USD billion)
1	Glencore	Switzerland	180
2	BHP[(1)]	Australia	60.8
3	Jiangxi Copper	China	48.8
4	Rio-Tinto	UK / Australia	44.6
5	Vale	Brazil	40.0
6	Anglo-American	UK / South Africa	30.9
7	Zijin Mining	China	25.3
8	Fortescue[(1)]	Australia	22.2
9	Nutrien	Canada	20.9
10	CMOC	China	16.64
11	MMC Norilsk Nickel	Russia	15.5
12	Freeport	USA	14.1
13	Newmont Goldcorp	USA	11.5
14	Southern Copper	USA	7.98
15	Barrick Gold	Canada	12.1
16	Shandong Gold Mining	China	9.22
17	The Mosaic Company	USA	8.68
18	Anglo American Platinum	South Africa	8.5
19	Sumitomo Metal Mining	Japan	7.17
20	Teck	Canada	6.65
21	South32	Australia	6.07
22	KGHM PMSA	Poland	5.5
23	First Quantum Minerals	Canada	5.2
24	Antofagasta plc	UK / Chile	5.13
25	Polyus	Russia	4.99
	Total		618.4

The data for Table 3 has been derived from the websites of corporations and by using the list of top 50 mining corporations by market capitalization published by MINING.COM as a reference (MINING.COM, 2021). (1) BHP and Forteque data are for 2021 as they follow a July to June business annual year

The reporting practices of the companies were evaluated as per the Sustainability Reporting Framework in Table 3, and the results are given below:

1. Economic Value

Table 4 indicates which corporations provide data on country-by-country Economic Value Generated and Distributed (EVG&D) as per GRI201-1 requirements and Tax Paid country by country as per GRI 207-4 requirements. GRI 201-1 includes data on economic value generated or revenue, economic value distributed across operating costs or payments to suppliers, employee wages and benefits, payments to providers of capital, payments to governments and community investments and economic value retained. In some cases, corporations provide country-by-country date EVG&D in part, for e.g., economic value distributed is given country by country but not generated or retained.

The scoring in Table 4 was awarded on the following basis. Corporations that provided complete data country-by-country were awarded the maximum score of 1, those that provided part country-by-country data 0.67, those that provided only taxes paid country by country 0.33, and those that did not provide any of the above 0. Three of the corporations operate only in one country so this category is not applicable to them (NA).

Based on the data in Table 4, the Industry Mean Transparency Index for Economic Performance was calculated as: (6.98/22)*100 = 32%.

Table 4. Evaluating economic performance transparency.

No.	Company	EVG&D country-by-country	EVG&D country-by-country in part	Tax country by country	Score out of 1
1	Glencore	N	N	Y	0.33
2	BHP	N	Y	Y	0.67
3	Jiangxi Copper	N	N	N	0
4	Rio Tinto	N	N	Y	0.33
5	Vale	N	N	Y	0.33
6	Anglo American	N	Y	Y	0.67
7	Zijin Mining	N	N	N	0
8	Fortesque	-	-	-	NA
9	Nutrien	N	N	N	0
10	CMOC	N	N	Y	0
11	Freeport	N	Y	Y	0.67
12	MMC Norilsk Nickel	N	N	N	0
13	Newmont Goldcorp	Y	Y	Y	1.0
14	Southern Copper	N	N	N	0
15	Barrick Gold	N	N	N	0
16	Shandong Gold Mining	N	N	N	0
17	The Mosaic Company	N	N	Y	0.33
18	Anglo American Platinum	N	N	Y	0.33
19	Sumitomo Metal Mining	N	N	Y	0.33
20	Teck	Y	Y	Y	1.0
21	South32	N	N	Y	0.33
22	KGHM	N	N	Y	0.33
23	First Quantum Minerals	N	N	Y	0.33
24	Antofagasta plc	-	-	-	NA
25	Polyus	-	-	-	NA
	Total				6.98
	Maximum				22

The data for Table 4 has been obtained from the related reports of the companies e.g., Economic contributions, Tax transparency, Sustainability that are available online on their corporate websites. Refer Appendix 2 for a list of these reports

2. GHG (Greenhouse gas) Emissions

Table 5 provides data for Greenhouse Gas (GHG) emissions from the operational activities of corporates as per the metrics in Table 3. Another metric that I considered including was GRI Disclosure 305-4 GHG emissions intensity. This is described in GRI standards on Emissions, 305 series (Global Reporting Initiative, 2022) as given below, indicating that this metric could be used to compare GHG efficiency between companies:

> GHG emissions intensity expresses the amount of GHG emissions per unit of activity, output, or any other organization-specific metric. In combination with an organization's absolute GHG emissions, reported in Disclosures 305-1, 305-2, and 305-3, GHG emissions intensity helps to contextualize the organization's efficiency, including in relation to other organizations. (Global Reporting Initiative, 2022).

However, my analysis showed that the data were not comparable. This is due to the organizational subjectivity of the disclosure. GRI describes 305-4 as an organization specific metric, in which the numerator can be Scope 1 or the addition of Scope 1+2 GHG emissions and the denominator is to be chosen by the organization, for e.g., no. of products produced, services provided or total sales. Inference from the data on this metric in Table 5 indicates that even if organizations use the same numerator (Scope 1+2 GHG emissions) and same denominator, such as tonnes of copper equivalent (written as Cueq) produced, the data between organizations are not comparable. This is deduced on the basis that if the data were comparable, there would have been a positive correlation between percentage renewable energy used, which is an indication of Scope 1+2 emissions, and GHG intensity. The reason this is not the case could be that organizations use different methodologies to convert total production of all metals into Cueq and have business models with varying activities conducted in-house and outsourced.

The scoring in Table 5 was awarded on the following basis: corporations that provided data on percentage renewable energy used and GHG scope 1&2 emissions in tons were awarded the maximum score of 1, those that provided either one of them a score of 0.5 and those that did not provide any of them a score of 0. While emissions intensity data is included in the table it was not included in the transparency scoring, as explained above.

Table 5. Evaluating transparency of GHG emissions.

No.	Company	% Renewable energy	GHG Scope 1&2 emissions in tons	Emissions intensity in tons (Scope 1&2)	Transparency score out of 1
1	Glencore	13.3	24.3	3.8 / t Cueq	1.0
2	BHP	0.3	16.2	2.2 / t Cueq	1.0
3	Jiangxi Copper	N	3.0	N	0.5
4	Rio Tinto	32.3	31.5	6.4 / t Cueq	1.0
5	Vale	32.1	10.3	0.026 / t MFe-eq	1.0
6	Anglo American	2.7	16.1	7.6 / t Cueq	1.0
7	Zijin Mining	2	6.1	35.63 / RMB million	1.0
8	Fortesque	N	2.2	3.5 / MT iron ore processed	0.5
9	Nutrien	0	13.2	0.59 / t product weighted average	0.5
10	CMOC	18.3	1.03	0.025 / t processed ore	1.0
11	Freeport	12.3	7.12	N	1.0
12	MMC Norilsk Nickel	46	9.7	8.68 / RUB mln	1.0
13	Newmont Goldcorp	7	3.3	0.63 / GoE	1.0
14	Southern Copper	N	N	N	0
15	Barrick Gold	2	7.3	0.89 / GoE	1.0
16	Shandong Gold Mining	N	0.78	12.39 / RMB million	0.5
17	The Mosaic Company	N	4.9	0.23 / t of finished product	0.5
18	Anglo American Platinum	N	3.9	0.18 / t milled	0.5
19	Sumitomo Metal Mining	0	2.8	0.65 / t of product	1.0
20	Teck	88	2.8	2.7 / t Cueq	1.0
21	South32	17	21.6		1.0
22	KGHM	0	5.2	N	1.0
23	First Quantum Minerals	36	4.3	5.88 / t Cueq	1.0
24	Antofagasta plc	19	2.3	3.19 / t Cueq	1.0
25	Polyus	76	2.0	0.045 / t ore processed	1.0
	Total				21
	Maximum				25

The data for Table 5 has been obtained from the related reports of the companies e.g., Climate Change, Sustainability, ESG data book available on their corporate websites as provided in Appendix 2

Based on the data in Table 5 the Mean Industry Transparency Index for GHG emissions was calculated as (21/25)*100 = 84%.

3. Waste and Tailings Transparency

Table 6 provides waste data from the operational activities of corporates as per the metrics in Table 3. The scoring in Table 6 was awarded on the following basis: the maximum score of 1, has been equally split across the four metrics below, with 0.25 for providing the data for each of the metrics of total mineral waste generated, % recycled or diverted from disposal, total number and volume of significant spills, and waste data given by site.

Based on the data in Table 6 the Industry Mean Transparency Index for mineral waste was calculated as (10.5/25)*100 = 42%.

Table 6. Evaluating mineral waste transparency.

No.	Company	Total mineral waste in million tons	Total mineral waste recycled/ diverted from disposal in % [(2)]	Total no. & volume (m3) of significant spills	Waste data given by site	Transparency score out of 1
1	Glencore	2026	1	2 / 54	N	0.75
2	BHP	198	N	0	N	0.5
3	Jiangxi Copper	55[(1)]	N	N	N	0.25
4	Rio Tinto	969	1	0	N	0.75
5	Vale	528	N	1 / 31	N	0.5
6	Anglo American	N	N	N	N	0
7	Zijin Mining	537	18	N	N	0.5
8	Fortesque	27[(1)]	N	N	N	0.25
9	Nutrien	27[(1)]	N	N	N	0.25
10	CMOC	150	N	N	N	0.25
11	Freeport	608	N	N	N	0.25
12	MMC Norilsk Nickel	144	26	N	N	0.5
13	Newmont Goldcorp	401	N	Y	Y	0.75
14	Southern Copper	N	N	N	N	0
15	Barrick Gold	505	N	N	N	0.5
16	Shandong Gold Mining	21	83	N	N	0.5
17	The Mosaic Company	263	74	6 > 2000 gallons	N	0.75

No.	Company	Total mineral waste in million tons	Total mineral waste recycled/ diverted from disposal in % [(2)]	Total no. & volume (m3) of significant spills	Waste data given by site	Transparency score out of 1
18	Anglo American Platinum	201	N	0	N	0.5
19	Sumitomo Metal Mining	6.8[(1)]	N	N	N	0.25
20	Teck	798	N	0	N	0.5
21	South32	46	2	N	N	0.5
22	KGHM	115	17	N	N	0.5
23	First Quantum Minerals	324	N	N	N	0.25
24	Antofagasta plc	493	N	N	N	0.25
25	Polyus	351	66	N	N	0.5
	Total					10.5
	Maximum					25

The data for Table 6 has been obtained from the related company reports e.g., Sustainability, ESG data of the corporations available on their corporate websites as given in Appendix 2 (1) indicates only Tailings given, overburden rock not included (2) indicates inclusion of waste used for reclamation

Table 7 provides tailings management data from the operational activities of corporates as per the metrics in Table 3. The scoring in Table 7 was awarded on the following basis- the maximum score of 1, has been equally split across two metrics with 0.5 each for providing site-wise tailings data, and for publicly aligning with GISTM guidelines for tailing management as per ICMM deadlines.

Based on the data in Table 7 the Industry Mean Transparency Index for Tailings Management was calculated as (15.5/25)*100 = 62%.

Table 7. Evaluating transparency in tailings management.

No.	Company	Site-wise tailings data (e.g., aligned with CoE disclosure requirements)	Publicly announced alignment with GISTM guidelines as per ICMM deadline	Score out of 1
1	Glencore	Y	Y	1.0
2	BHP	Y	Y	1.0
3	Jiangxi Copper	N	N	0
4	Rio Tinto	Y	Y	1.0
5	Vale	Y	Y	1.0
6	Anglo American	Y	Y	1.0
7	Zijin Mining	N	N	0
8	Fortesque	Y	Y	1.0
9	Nutrien	N	N	0
10	CMOC	N	N	0
11	Freeport	Y	Y	1.0
12	MMC Norilsk Nickel	Y	N	0.5
13	Newmont Goldcorp	Y	Y	1.0
14	Southern Copper	N	N	0
15	Barrick Gold	Y	Y	1.0
16	Shandong Gold Mining	N	N	0
17	The Mosaic Company	N	N	0
18	Anglo American Platinum	Y	Y	1.0
19	Sumitomo Metal Mining	N	Y	0.5
20	Teck	Y	Y	1.0
21	South32	Y	Y	1.0
22	KGHM	Y	N	0.5
23	First Quantum Minerals	Y	N	0.5
24	Antofagasta plc	N	Y	0.5
25	Polyus	Y	Y	1.0
	Total			15.5
	Maximum			25

The data for Table 7 has been obtained from the related company reports e.g., Sustainability, ESG data available on their corporate websites as given in Appendix 2

4. Land and Biodiversity

Table 8 provides land data from the operational activities of corporates as per the metrics in Table 3. The scoring in Table 8 was awarded on the following basis: the maximum score of 1, has been equally split across the three metrics below, with 0.33 each for total land disturbed and not rehabilitated, land disturbed and rehabilitated in the reporting year, and land data given by site.

Table 8. Evaluating transparency in land impacts.

No.	Company	Total land disturbed and not rehabilitated at end of 2020 (Ha)	Land disturbed / rehabilitated in 2020 (Ha)	Land data by site	Score out of 1
1	Glencore	95,000	2046 / 1986	N	0.67
2	BHP	147,791	N	N	0.33
3	Jiangxi Copper	N	N	N	0
4	Rio Tinto	313,800	N	N	0.33
5	Vale	62,479	1273 / 1603	N	0.67
6	Anglo American	81,605	N	N	0.33
7	Zijin Mining	11,491	956 / 401	N	0.67
8	Fortesque	41,888	N	N	0.33
9	Nutrien	N	N	N	0
10	CMOC	N	N	N	0
11	Freeport	61862	587 / 90	N	0.67
12	MMC Norilsk Nickel	17243	704 / 0	N	0.67
13	Newmont Goldcorp	20624	529 / 56	Y	1
14	Southern Copper	N	N	N	0
15	Barrick Gold	49,664	460 / 1298	N	0.67
16	Shandong Gold Mining	N	N	N	0
17	The Mosaic Company	142,000	16861 / 2491	N	0.67
18	Anglo American Platinum	6188	N / 38	N	0.33
19	Sumitomo Metal Mining	870	6 / 0	N	0.67
20	Teck	27648	1094 / 212	N	0.67
21	South32	5815	225 / 251	N	0.67
22	KGHM	N	N	N	0
23	First Quantum Minerals	20595	N	N	0.67
24	Antofagasta plc	N	N	N	0
25	Polyus	26028	1736 / 227	N	0.67
	Total				10.69
	Maximum				25

The data for Table 8 has been obtained from the related company reports e.g., Sustainability, ESG data available on their corporate websites as given in Appendix 2

Based on the data in Table 8 the Industry Mean Transparency Index for Land impacts was calculated as (10.69/25)*100 = 43%

5. Water

Table 9 provides water consumption data from the operational activities of corporates as per the metrics in Table 3. The definition of water consumption as per GRI 303 Water and Effluent series (Global Reporting Initiative, 2022) is given below:

> Water consumption measures water used by an organization such that it is no longer available for use by the ecosystem or local community in the reporting period. Reporting the volume of water consumption can help the organization understand the overall scale of its impact due to water withdrawal on downstream water availability.

The scoring in Table 9 was awarded on the following basis: the maximum score of 1, has been equally split across the five metrics below, with 0.2 for providing data for each of the metrices of total water consumption, % from high stress areas, water data given by site, % water recycled, and number of water related non-compliance incidents.

Based on the data in Table 9 the Industry Transparency Index for Water was calculated as (13.8/25)*100 = 56%.

A significant issue in water data was that corporations utilize different reporting frameworks like GRI, ICMM and Australia's Water Accounting Framework. These follow different definitions and methodologies, making comparisons between water data of corporations difficult.

Table 9. Evaluating water consumption transparency.

No.	Company	Total water consumed million m3	% From high stress area	Water data given by site	% Water recycled	No. of water non-compliance incidents	Transparency score out of 1
1	Glencore	372	24	Y	34	N	0.8
2	BHP	267	40	Y	49	3	1.0
3	Jiangxi Copper	45[(1)]	N	N	95	N	0.4
4	Rio Tinto	524	35	N	39	N	0.6
5	Vale	124	N	N	80	11	0.6
6	Anglo American	123	N	N	80	N	0.4
7	Zijin Mining	51	13	N	92	N	0.6
8	Fortesque	52	0	N	N	N	0.4
9	Nutrien	362	1.1	N	N	2	0.6
10	CMOC	23[(1)]	N	N	82	N	0.4
11	Freeport	167	N	N	82	0	0.6
12	MMC Norilsk Nickel	204[(1)]	N	N	86	N	0.4
13	Newmont Goldcorp	102	32	Y	71	N	0.8
14	Southern Copper	N	N	N	70	N	0.2
15	Barrick Gold	117	N	N	79	N	0.4
16	Shandong Gold Mining	7	N	N	N	N	0.2
17	The Mosaic Company	123[(1)]	N	N	93	N	0.4
18	Anglo American Platinum	22[(2)]	N	N	60	N	0.4
19	Sumitomo Metal Mining	35[(2)]	N	Y[(2)]	N	N	0.4
20	Teck	58	19	Y	73	0	1.0
21	South32	56	29	Y	62	1	1.0
22	KGHM	60	N	N	N	N	0.2
23	First Quantum Minerals	118[(2)]	1	Y[(2)]	67	N	0.8
24	Antofagasta plc	68	100	N	78-96	N	0.6
25	Polyus	23	0	N	94	N	0.6
	Total						13.8
	Maximum						25

The data for Table 9 has been obtained from the related company reports e.g., Sustainability, ESG data available on their corporate websites as given in Appendix 2 (1) Total water consumed calculated from total water used minus water recycled (2) Total water consumed not given, the data in the table is for total water withdrawn

6. Air Pollution

Table 10 provides air pollution data from the operational activities of corporates as per the metrics in Table 3. The scoring in Table 10 was awarded on the following basis: corporations that provided data on total air pollution across sites, split by pollutant and a break-up of this data by each site, are awarded the maximum score of 1, those that

provide only total air pollution data without break-up by sites a score of 0.5, and those that provide none of the above a score of 0.

Table 10. Evaluating transparency in air pollution.

No.	Company	GRI 305-7 Air pollution total by pollutants	Air pollution by pollutants by site	Score out of 1
1	Glencore	Y	N	0.5
2	BHP	Y	N	0.5
3	Jiangxi Copper	N	N	0
4	Rio Tinto	Y	N	0.5
5	Vale	Y	N	0.5
6	Anglo American	Y	N	0.5
7	Zijin Mining	N	N	0
8	Fortesque	Y	N	0.5
9	Nutrien	Y	N	0.5
10	CMOC	N	N	0
11	Freeport	Y	N	0.5
12	MMC Norilsk Nickel	Y	N	0.5
13	Newmont Goldcorp	Y	Y	1.0
14	Southern Copper	N	N	0
15	Barrick Gold	N	N	0
16	Shandong Gold Mining	Y	N	0.5
17	The Mosaic Company	Y	N	0.5
18	Anglo American Platinum	Y	N	0.5
19	Sumitomo Metal Mining	Y	N	0.5
20	Teck	Y	Y	0.5
21	South32	Y	N	0.5
22	KGHM	N	N	0
23	First Quantum Minerals	Y	Y	1.0
24	Antofagasta plc	N	N	0
25	Polyus	Y	N	0.5
	Total			10
	Maximum			25

The data for Table 10 has been obtained from the related reports of the companies e.g., Sustainability, ESG data book of the corporations available on their corporate websites as given in Appendix 2

Based on the data in Table 10 the Industry Transparency Index for Air Pollution was calculated as (10/25)*100 = 40%.

Evidently many corporations provide total air pollution data, but very few provide these data by site. This makes the information useless for those most impacted by the air pollution, the communities around the mining and processing sites.

7. Safety and Health of Workers

Table 11 provides safety and health data of workers related with the operational activities of corporates as per the metrics in Table 3. The scoring in Table 11 was awarded on the following basis: the maximum score of 1 has been equally split across the three metrics below, with 0.33 each for total number of fatalities in the year, total recordable injury frequency rate, and occupational disease frequency rate.

Table 11. Evaluating transparency of safety and health of workers.

No.	Company	Fatalities in the year GRI	Total Recordable Injury Frequency Rate (TRIFR)	Occupational disease frequency rate	Transparency index
1	Glencore	8	2.6	0.37	1
2	BHP	0	3.7	4.4 for employees / 1.9 for contractors	1
3	Jiangxi Copper	0	0.029 per 1000 persons per month	N	0.67
4	Rio Tinto	0	1.85	15.7 per 10,000 employees	1
5	Vale	4	1.97	N	0.67
6	Anglo American	2	2.14	30 new cases in 2020	1
7	Zijin Mining	2	0.7	N	0.67
8	Fortesque	0	2	0 for employees / 0.2 for contractors	1
9	Nutrien	0	5.5	N	0.67
10	CMOC	2	1.25	N	0.67
11	Freeport	5	3.45	N	0.67
12	MMC Norilsk Nickel	8	0.28	2.21	1
13	Newmont Goldcorp	0	1.65	0.35	1
14	Southern Copper	N	0.49	0.17	0.67
15	Barrick Gold	1	1.68	N	0.67
16	Shandong Gold Mining	0	N	N	0.33

No.	Company	Fatalities in the year GRI	Total Recordable Injury Frequency Rate (TRIFR)	Occupational disease frequency rate	Transparency index
17	The Mosaic Company	0	3.65 employee/1.62 contractor	1.65 employees / 0.35 contractors	1
18	Anglo American Platinum	1	2.4	4 new cases in 2020	1
19	Sumitomo Metal Mining	0	Japan - 1.13 employees / 4.07 contractors; Overseas - 0.0 employees / 0.28 contractors	0	1
20	Teck	2	3.65	1.57	1
21	South32	1	4.3	1.1	1
22	KGHM	0	2.5	N	0.67
23	First Quantum Minerals	0	1.5	N	0.67
24	Antofagasta plc	0	2.75	0	1
25	Polyus	1	1.45	0.045	1
	Total				21
	Maximum				25

The data for Table 11 has been obtained from the related company reports e.g., Sustainability, ESG data available on their corporate websites as given in Appendix 2

Based on the data in Table 11 the Industry Transparency Index for Workforce relations was calculated as (21/25)*100 = 84%.

8. Workforce Relations

Table 12 provides workforce data from the operational activities of corporations as per the metrics in Table 3. The scoring in Table 12 was awarded on the following basis: the maximum score of 1, has been equally split across two metrics with 0.5 each for information on % of workers covered under collective bargaining agreements, and number and duration of strikes and lockouts exceeding a duration of one week in the reporting period.

Table 12. Evaluating transparency of workforce relations.

No.	Company	% of workers covered under collective bargaining agreements.	Number and duration of strikes and lockouts exceeding 1 week	Transparency index
1	Glencore	73	1	1
2	BHP	51	1	1
3	Jiangxi Copper	100	N	0.5
4	Rio Tinto	N	0	0.5
5	Vale	96	0	1
6	Anglo American	70	0	1
7	Zijin Mining	N	N	0
8	Fortesque	42	N	0.5
9	Nutrien	19	N	0.5
10	CMOC	45	N	0.5
11	Freeport	38	0	1
12	MMC Norilsk Nickel	94	0	1
13	Newmont Goldcorp	47	0	1
14	Southern Copper	N	N	0
15	Barrick Gold	40	N	0.5
16	Shandong Gold Mining	N	N	0
17	The Mosaic Company	76	0	1
18	Anglo American Platinum	N	N	0
19	Sumitomo Metal Mining	N	N	0
20	Teck	54	0	1
21	South32	52	0	1
22	KGHM	89	N	0.5
23	First Quantum Minerals	N	N	0
24	Antofagasta plc	78	0	1
25	Polyus	96	N	0.5
	Total			15
	Maximum			25

The data for Table 12 has been obtained from the related company reports e.g., Sustainability, ESG data available on their corporate websites as given in Appendix 2

Based on the data in Table 12 the Industry Transparency Index for Workforce relations was calculated as (15/25)*100 = 60%

9. Diversity

Table 13 below provides female diversity data in the workforce of the 25 corporations as per the metrics in Table 3.

Table 13. Evaluating transparency of female diversity.

No.	Company	% of women in total workforce	Score out of 1
1	Glencore	16	1
2	BHP	28	1
3	Jiangxi Copper	15	1
4	Rio Tinto	19	1
5	Vale	16	1
6	Anglo American	23	1
7	Zijin Mining	16	1
8	Fortesque	21	1
9	Nutrien	20	1
10	CMOC	14	1
11	Freeport	13	1
12	MMC Norilsk Nickel	29	1
13	Newmont Goldcorp	13	1
14	Southern Copper	N	0
15	Barrick Gold	10	1
16	Shandong Gold Mining	20	1
17	The Mosaic Company	15	1
18	Anglo American Platinum	20	1
19	Sumitomo Metal Mining	18	1
20	Teck	20	1
21	South32	18	1
22	KGHM	N	0
23	First Quantum Minerals	10	1
24	Antofagasta plc	12	1
25	Polyus	15	1
	Total		23
	Maximum		25

The data for Table 13 has been obtained from the related company reports e.g., Sustainability, ESG data available on their corporate websites as given in Appendix 2

Based on the data in Table 13 the Industry Transparency Index for female diversity was calculated as (23/25)*100 = 92%.

10. Credibility of Sustainability Reports

Table 14 below provides credibility data of sustainability reports of companies as per the metrics in Table 3. The scoring in Table 14 for third-party assurance from a qualified validation service provider, was awarded on the following basis: 0.25 for

obtaining a limited or moderate level of assurance on selected parameters but not sharing the assurance statement; 0.5 for obtaining a limited or moderate level of assurance on selected parameters and sharing the assurance statement; 0.75 for obtaining a limited or moderate level of assurance on selected parameters and reasonable or high level on some parameters and sharing the assurance statement; 1.0 for obtaining a reasonable or high level on identified material parameters and sharing the assurance statement. Sharing of assurance statement above means including it in the company sustainability report or company's website.

Table 14. Evaluating credibility of sustainability disclosures.

No.	Company	Limited / moderate assurance mentioned on selected parameters - statement not shared	Limited / moderate assurance mentioned on selected parameters - statement shared	Limited / moderate on some parameters and reasonable / high on others – statement shared	Reasonable / high on all material parameters – statement shared	Score out of 1
1	Glencore		Y			0.5
2	BHP			Y		0.75
3	Jiangxi Copper	N				0
4	Rio Tinto	Y				0.25
5	Vale		Y			0.5
6	Anglo American			Y		0.75
7	Zijin Mining		Y [(1)]			0.63 [(1)]
8	Fortesque	Y				0.25
9	Nutrien		Y (only for GHG)			0.5
10	CMOC		Y			0.5
11	Freeport		Y			0.75
12	MMC Norilsk Nickel		Y			0.5
13	Newmont Goldcorp		Y			0.5
14	Southern Copper	N				0
15	Barrick Gold			Y		0.75
16	Shandong Gold Mining	N				0
17	The Mosaic Company		Y			0.5
18	Anglo American Platinum			Y		0.75

No.	Company	Limited / moderate assurance mentioned on selected parameters - statement not shared	Limited / moderate assurance mentioned on selected parameters - statement shared	Limited / moderate on some parameters and reasonable / high on others – statement shared	Reasonable / high on all material parameters – statement shared	Score out of 1
19	Sumitomo Metal Mining		Y			0.5
20	Teck		Y			0.5
21	South32			Y		0.75
22	KGHM	N				0
23	First Quantum Minerals	N				0
24	Antofagasta plc		Y			0.5
25	Polyus		Y			0.5
	Total					11.13
	Maximum					25

The data for Table 14 has been obtained from the related company Sustainability reports available on their corporate websites as given in Appendix 2(1) Zijin assurance statement included in its sustainability report has been developed as per the Honk Kong stock market guidelines. It mentions reasonable verification and not assurance, due to this lack of clarity it has been given an intermediary ranking.

Based on the data in Table 14 the Industry Credibility Index for sustainability disclosures was calculated as (11.13/25)*100 = 43%.

Evaluating Hypothesis H1

Hypothesis H1 proposed that less than 10% of the corporations adhere to the industry best practice of providing third party reasonable / high assurance on the material parameters identified by them in their sustainability reports. Table 13 shows that not a single company (0% of companies) are getting all their material sustainability impacts assured at this level, thus confirming hypothesis H1.

The above implies that state of third-party assurance of the data in sustainability reports of the top 25 mining companies globally is abysmally low. This may be better solved by taking a step back and first focusing on developing standardized methodologies

and processes for the disclosures. There have been some efforts on this by GRI and SASB, but there continue to be wide differences on how companies arrive at their disclosures. It is also important to define a limited set of disclosures that would need third party assurance. GRI has hundreds of disclosures, and this is too wide a scope for obtaining third party assurance. SASB has a limited set of disclosure requirements, but they are focused only on the needs of investors.

Evaluating Hypothesis H2

Table 15 provides a ranking of Industry Mean Transparency Index of each sustainability category (MTI_{SC}^{n}) as evaluated from Tables 4 to 14 above.

Table 15. Industry Mean Transparency Index of each sustainability category (MTI_{SC}^{n}).

Sustainability category	Mean Transparency Index %	Ranking
Female diversity	92	1
GHG emissions	84	2
Health & Safety	84	2
Tailings Management	62	4
Labor relations	60	5
Water	55	6
Land impacts	43	7
Mineral waste	42	8
Air Pollution	40	9
Economic impacts	32	10
Mean	59	

Hypothesis H2 proposed that the Industry Mean Transparency Index of all sustainability categories (MTI_{SC}) will be below 50%. Table 14 above shows this to be 59% thus refuting hypothesis H2. This implies that at an average 59% of the data were provided under each sustainability category by the companies evaluated as compared

with the Industry Best Practice Framework. However, the data also showed the wide variation of the transparency index between the categories as explained below.

The rankings in Table 15 indicate that disclosures on % of females in the work force, GHG emissions and health & safety are commonly reported. The sustainability framework did not include any site level disclosures for these three topics. The next transparency rankings cover tailings management, labor relations and water respectively. Tailings management disclosures include information on every tailings dam of the company and its relatively high ranking indicates that the 2019 tailings dam disaster in Brazil has impacted the industry to improve disclosures in tailings management. The framework included two basic metrics on labor relations and together they have an intermediate level of reporting. The significance of water impacts as a substantial business risk is widely accepted today and the quality and extent of disclosures on this topic are rising; however, reporting site level water data is still not widespread.

At the bottom end of the transparency index are the categories of land impacts, mineral waste which includes overburden rock and tailings, air pollution and economic value generated and distributed (EVG&D) in that order. Land, mineral waste and air pollution include site level data but there is minimal reporting on these. For EVG&D the framework includes country-by-country data and evidently this is poorly reported. Seven of the organizations that do not provide the EVG&D data as per the GRI format, do provide country-by-country tax transparency, perhaps propelled by other frameworks like OECD and EITI that insist on transparency in payments to Governments.

The wide variation in corporates reporting on female diversity and economic impacts (92% and 32%respectively) is indicative of an underlying propensity for

companies to report on some specific topics and not on others. The anomaly becomes even more striking when one considers the significance of economic impacts as they concern a vast no. of stakeholders such as investors, employees, suppliers, and communities.

Evaluating hypothesis H3

Table 16 provides a ranking of Transparency Index of company's sustainability performance (CTI_m) incorporating sustainability category weightages given in Figure 4. The detailed scoring can be seen in the Appendix.

Table 16. Transparency Index of company's sustainability performance (CTI_m).

Company	Country	Company Transparency index (CTI_m) %	Ranking
Newmont	USA	90	1
Teck	Canada	85	2
BHP	Australia	79	3
South 32	Australia	75	4
Polyus	Russia	73	5
Glencore	Switzerland	72	6
Freeport	USA	71	7
Anglo American	South Africa	68	8
Vale	Brazil	63	9
Rio Tinto	Australia	61	10
Antofagasta plc	Chile	59	11
Anglo American Platinum	South Africa	57	12
Fortesque	Australia	56	13
The Mosaic Company	USA	55	14
Sumitomo Metal Mining	Japan	55	14
MMC NorNickel	Russia	54	16
Barrick Gold	Canada	53	17
First Quantum Minerals	Canada	52	18
Zijin Mining	China	44	19
Nutrien	Canada	35	20
CMOC	China	35	20
KGHM	Poland	35	20
Jiangxi Copper	China	25	23
Shandong Gold Mining	China	20	24
Southern Copper	USA	10	25
Mean		55	
Median		56	

Hypothesis H3 predicted that the Industry Mean Transparency Index of all companies' sustainability performance (MTI_{CSP}) will be lower than 50%, implying that half of the top 25 companies will not be reporting even 50% of the data as compared to the industry best practice framework. Table 16 above evaluates this at 56%, thus not supporting hypothesis H3. However, the fact that the median is 56% is indicative of low level of data provided by about from half of the companies in the sample. A maximum of 90% and minimum of 10% shows a large variation in the reporting practices between companies.

Figure 5 shows the distribution of the Transparency Index of sustainability performance for the 25 companies (CTI_m). The graph shows a near normal distribution, a mean of 55 and standard deviation of 20, indicating that there is a 68% probability that the transparency index of a company lies between 35 and 75 as per the best practice

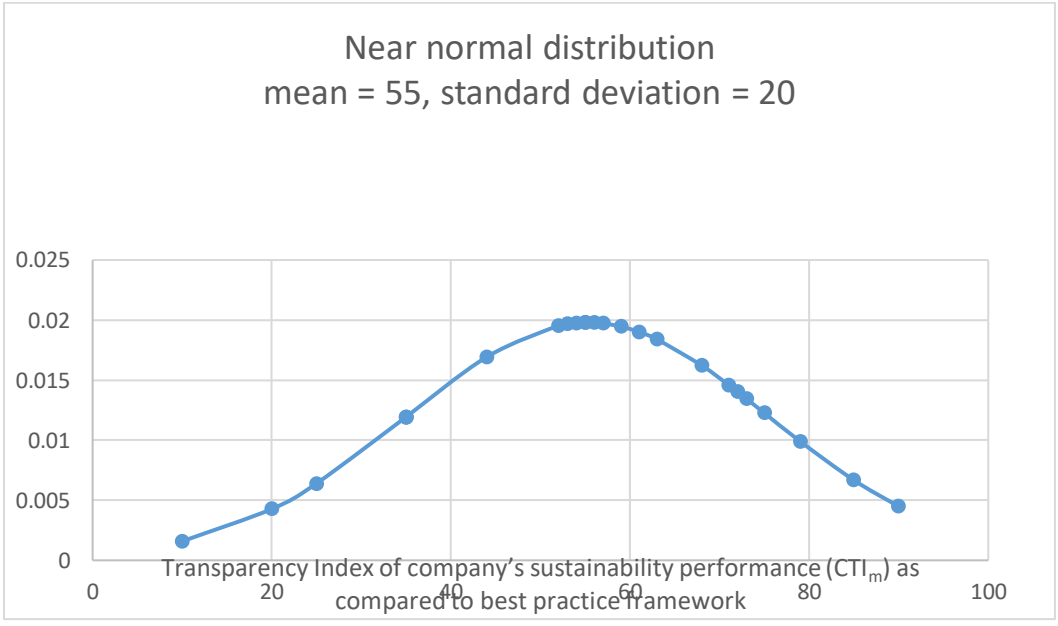

Figure 5. Distribution graph of transparency index of company's sustainability performance (CTI_m).

framework. This implies a wide variation between reporting practices of the companies and a high potential for companies to improve with respect to the existing best practices in sustainability performance reporting today.

Evaluating Company Transparency by Country of Headquarters

Table 17 shows the mean company rankings for each of the countries where the top 25 corporates are located.

Table 17. Country sustainability performance transparency rankings for the metals and mining industry.

Country	No. of companies assessed	Mean transparency index %	Ranking
Switzerland	1	72	1
Australia	4	68	2
Russia	2	64	3
South Africa	2	62	4
South America (Brazil & Chile)	2	61	5
USA	4	57	6
Canada	4	56	7
Japan	1	55	8
Poland	1	35	9
China	4	31	10
Total	25		

Switzerland tops the list at 72% mean transparency index, but with a sample size of only one company, Glencore, it cannot be considered representative of the country.

The four companies from Australia have the next highest mean transparency index at 68% indicating that the country has relatively matured sustainability reporting practices.

The four companies from USA have a mean transparency index of 57%. They are widely spread out across the rankings, occupying the top and the bottom ranks, indicating

a wide variation in the commitment of the companies to voluntary sustainability reporting in the country.

The four companies from Canada have a mean transparency index of 56% and are spread out across the rankings indicating no specific trend on the quality of sustainability reporting practices. A point to consider is that the Canadian company with the lowest rank, that is Nutrien, is a fertilizer mining company and it is possible that the set of metals and mining industry disclosures developed for the best practice framework are not suitable for its reporting requirements and therefore responsible for its low rankings.

The four companies from China have a mean transparency index of 31% and are placed toward the bottom end of the rankings, indicating that while voluntary sustainability reporting is present in China, it is not aligned with or has not matured with respect to the granularity of data required by GRI, SASB and ICMM standards.

The two companies each from Russia, South Africa and South America are within the first half of the rankings indicating relatively well-established reporting practices in these countries.

Like Switzerland, Japan and Poland have only one company each and are therefore not commented on.

Evaluating Hypothesis H4

Table 18 shows the companies reporting site level data for the relevant topics as per the best practices framework. As there are four categories with the requirement of site level data and there are 25 companies being assessed, the possible maximum value is 100.

Table 18. Evaluating transparency in mining site level data.

No.	Site level metrics	Companies providing the metrics	No. of companies providing the metrics
1.	Mineral waste produced at every site	Newmont	1
2.	Land disturbed and rehabilitated at every site	Newmont	1
3.	Water use data for every site	Glencore BHP Newmont Sumitomo Teck South 32 First Quantum Minerals	7
4.	Air pollution at every site	Newmont Teck First Quantum Minerals	3
	Total disclosures made across the 4 metrics		12
	Maximum total site level disclosures across 25 corporates		100

Hypothesis H4 proposed that less than 20% of relevant site level data is being provided by corporates. Table 17 shows that only 12 of the 100 possible site level disclosure were reported in 2020. The transparency index for site-level data is calculated as = 100x(12/100) = 12%, thus supporting hypothesis H4.

This implies that the needs of local communities and civil society are not met by sustainability reporting practices. Without knowing the impacts that corporates are causing on "the common resources" of air, water, and land, they are not empowered to defend abnegation of their rights such as pollution of local eco-systems. GRI specifically claims its core constituency comprises wide range of stakeholders (Global Reporting Initiative, 2022) and could therefore pay more attention to this.

In addition to the need to enhance credibility, sufficiency, and relevance of information this thesis also proposes to enhance simplicity, comparability, and accessibility of sustainability disclosures, as explained in the section below.

The Next-level Sustainability Reporting Dashboard

The topic of sustainability reporting is vast and complex, as is that of ESG disclosures (Kell & Cort, 2021). Straddling across economic, environmental, social and governance issues, aspects such as management approach, policies, past performance, and future targets, while aiming to satisfy a host of stakeholders, sustainability reporting has become confusing. Coupled with hardly any mandatory requirements or standardized templates across national and international jurisdictions, they are difficult to navigate through, often leaving one befuddled.

It is for these reasons that I propose that a limited but standard set of industry specific performance disclosures should be presented at the start of all sustainability reports. This is not to say that these are the only disclosures that need to be reported. The vast number of remaining disclosures and details should be included in the rest of the report. Navigation of the report would then become similar to a company's financial report, wherein the profit and loss (P&L) statement is generally presented in the beginning of the report. The P&L statement aims to inform on the efficiency with which an organization deploys the financial capital available to it based on a standardized format. It is what most readers have the capacity and inclination to focus on, while those interested in more nuanced analysis have the complete report to peruse. Similarly, the first section of a sustainability report should aim to inform on the efficiency with which the organization deploys natural capital. This is important as the planet has limited

natural resources – including limited sinks to absorb waste – and natural resources are often “local commons”; they belong to the entire local population. In the case of GHG emissions, they impact the earth’s atmosphere, which is a “global commons”.

The next-level framework described below is based on the principles of transparency and data quality already discussed in this thesis: sufficiency of data on material impacts, relevance to stakeholders, simplicity, and comparability. It is worthwhile to reiterate that the focus of the framework is only on performance indicators of the reporting period. For comparability, the focus is on data that indicates efficiency in the utilization of natural and social capital which requires product level metrics or business intensity ratios to illuminate and compare critical dimensions of sustainability performance across companies (Esty & Lubin, 2020). Social data for health & safety is already reported in intensity ratios like Total Recordable Injury Frequency Rate (TRIFR) or Occupational illness rate per million hours worked. For natural capital the relevant efficiency ratios would be in terms of natural capital utilized or pollution created per unit produced. For example, carbon emissions or water used per ton of copper produced. Total carbon emissions or total water used by the company cannot provide such insights. This has its challenges as explained below, but it is the required direction for development of effective disclosures for future reporting.

The Challenge of Measuring Efficiency of Natural Capital

As mentioned above, efficiency of utilizing natural capital indicates the intensity usage of natural resources and sinks. The main use of this is the ability to compare efficiency performance between companies, but this would be meaningful only if they were evaluated considering the same mining and refining stages across companies. In

reality companies have their own unique business models, carrying out different activities within their own operations and outsourcing others. Thus, comparing efficiency ratios derived from only company data would be erroneous. Most large corporations also produce several metals in different ratios adding further complexity.

The environmental Life Cycle Analysis concept aims to solve this by including natural capital used in the specific product's entire life cycle from mineral extraction to all processing and manufacturing activities, whether they were carried out inhouse or outsourced. The challenge in this is that natural capital usage data from suppliers are usually unavailable. Life cycle analysis methodologies therefore use secondary data for most activities in supply chains; this comprises obtaining industry averages on natural capital utilization for various processes from databases that have been developed for this purpose, like Ecoinvent (ecoinvent, n.d.). This also has a problem; it reduces the incentive for companies that aim to obtain transparency and work on improving natural capital utilization in their supply chains. One way to solve this could be to make it mandatory for companies to report efficiency intensity ratios across the product's manufacturing processes for each of the metals they produce, along with the percentage of primary data used in evaluating the respective sustainability category intensity ratio. The reward mechanism in financial or consumer markets or any other regulatory framework should include a weightage not only for which company uses less natural capital to produce the same amount of metal, but also the percentage of primary data used in calculating this.

Best Practice Examples of Sustainability Disclosures

Below are some best practice examples through which companies are setting new benchmarks in depicting sustainability disclosures either in the granularity of country and site level data or in product level / business intensity impacts per unit manufactured. They are the best illustrations of the feasibility of companies providing data on EVG&D (Table 19), and site-level data on water intensity (Table 20), CO2eq emissions (Figure 6), air pollutant emissions (Table 21) and land impacts (Figure 7).

Table 19. Best practice reporting of EVG&D country by country, Teck, 2020.

	Economic Value Generated	Economic Value Distributed								Economic Value Retained
	Revenues[1]	Payments to Suppliers[2]		Employee Wages and Benefits[3]		Payments to Providers of Capital[4]	Income and Resource Taxes[5]	Community Investments[6]	Total	
		Operating Costs	Capital Expenditures	Operating Costs	Capital Expenditures					
Canada	$ 6,437	$ 4,441	$ 1,161	$ 1,161	$ 15	$ 606	$ 41	$ 10	$ 7,435	$ (998)
USA	1,521	782	161	140	4	8	53	1	1,149	372
Chile	558	274	1,629	90	47	50	21	6	2,117	(1,559)
Peru	896	253	100	100	-	2	118	0.5	573	323
Other	-	16	12	4	-	1	-	1	34	(34)
Inter-segment elimination[1]	(464)	(464)	-	-	-	-	-	-	(464)	-
Total	**$ 8,948**	**$ 5,302**	**$ 3,063**	**$ 1,495**	**$ 66**	**$ 667**	**$ 233**	**$ 19**	**$ 10,846**	**$ (1,896)**

The table is taken from Teck Sustainability Report of 2020 available on the company's website (Teck, 2021).

Table 20. Water intensity data by product, Nutrien 2020.

ENVIRONMENT (continued)	Units	2020
Freshwater consumption intensity – company-wide	m^3 per tonne product (weighted average)	16.1
Potash freshwater consumption intensity	m^3 per tonne KCl produced	0.7
Nitrogen freshwater consumption intensity	m^3 per tonne N produced	7.0
Phosphate freshwater consumption intensity	m^3 per tonne P_2O_5 produced	218.8
Specialty Product freshwater consumption intensity (feed plants, Loveland Products, Inc. and Rainbow facilities)	m^3 per tonne saleable product (weighted average)	0.3

The data is provided by Nutrien in its 2021 sustainability report (Nutrien, 2022)

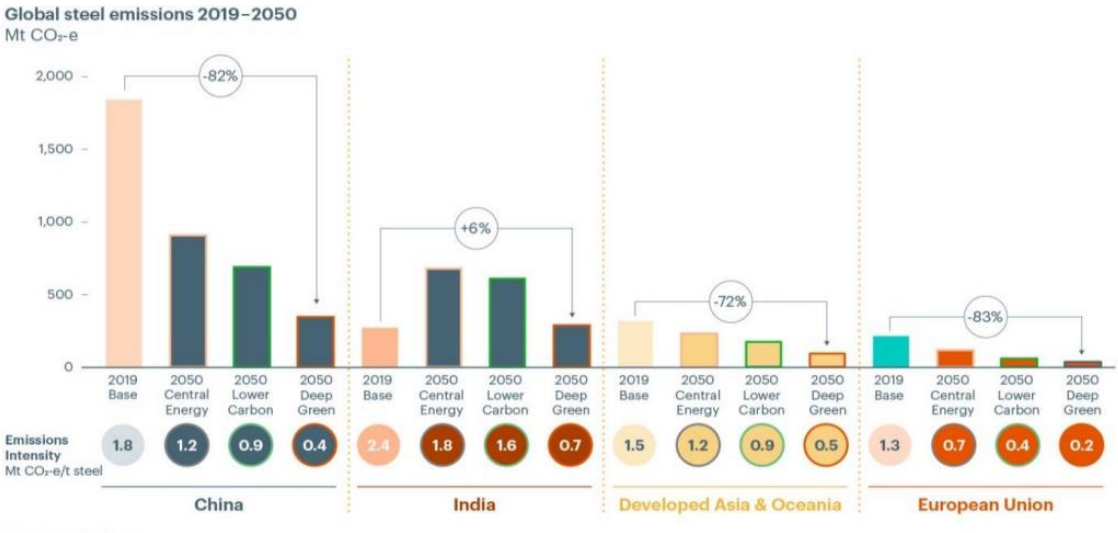

Figure 6. CO2eq steel production emission intensity data, BHP 2020.

The data is provided by BHP in its 2021 climate transition plan report (BHP, 2021)

Table 21. Air emissions by site, Newmont 2020.

AIR QUALITY

Air quality: Site level (tonnes)[1, 2]

	Country/site	Sulphur oxides (SO_x)	Nitrogen oxides (NO_x)	Particulate matter (PM10)	Carbon monoxide (CO)	Mercury (Hg)	Arsenic (As)	Lead (Pb)	Selenium (Se)	Persistent organic pollutants (POPs)	Volatile organic compounds (VOCs)
Africa	**Ghana**	**30.31**	**155.30**	**26.51**	**556.70**	**0.00**	**0.00**	**1.27**	**0.18**	**N/R**	**0.04**
	Ahafo	10.11	50.13	16.00	245.23	0.00	0.00	0.07	0.00	N/R	0.00
	Akyem	20.20	105.17	10.51	311.47	0.00	0.00	1.20	0.18	N/R	0.04
Americas: North	**U.S.**	**5.44**	**860.92**	**442.71**	**545.22**	**De minimis**	**N/R**	**N/R**	**N/R**	**N/R**	**353.80**
	CC&V	5.44	860.92	442.71	545.22	De minimis	N/R	N/R	N/R	N/R	353.80
	Canada	**7.90**	**1,528.70**	**395.30**	**632.70**	**0.10**	**0.00**	**0.20**	**0.00**	**0.00**	**7.50**
	Éléonore	5.70	114.80	151.80	120.40	N/R	N/R	N/R	N/R	N/R	5.20
	Musselwhite	1.70	285.70	100.20	203.70	0.00	0.00	0.10	0.00	0.00	2.30
	Porcupine	0.50	1,128.20	143.30	308.60	0.10	0.00	0.10	0.00	0.00	0.00
	Mexico	**6.00**	**2,504.40**	**3,473.90**	**2,059.60**	**0.00**	**0.00**	**2.60**	**0.00**	**0.00**	**12.10**
	Peñasquito	6.00	2,504.40	3,473.90	2,059.60	0.00	0.00	2.60	0.00	0.00	12.10
Americas: South	**Argentina**	**0.13**	**132.93**	**255.03**	**112.38**	**De minimis**	**0.00**	**0.00**	**0.00**	**0.00**	**0.65**
	Cerro Negro	0.13	132.93	255.03	112.38	De minimis	0.00	0.00	0.00	0.00	0.65
	Suriname	**822.04**	**2,173.27**	**110.34**	**154.60**	**0.01**	**0.00**	**N/R**	**N/R**	**N/R**	**N/R**
	Merian	822.04	2,173.27	110.34	154.60	0.01	0.00	N/R	N/R	N/R	N/R
	Peru	**0.16**	**0.20**	**0.25**	**0.49**	**0.15**	**0.07**	**0.01**	**N/R**	**N/R**	**N/R**
	Yanacocha	0.16	0.20	0.25	0.49	0.15	0.07	0.01	N/R	N/R	N/R
Australia	**Australia**	**4.36**	**3,251.27**	**13,259.47**	**1,676.48**	**0.00**	**2.42**	**0.45**	**0.07**	**0.00**	**291.24**
	Boddington	3.56	1,995.32	11,605.98	935.04	0.00	1.16	0.37	0.07	N/R	137.46
	Tanami	0.80	1,255.95	1,653.49	741.44	0.00	1.26	0.08	N/R	N/R	153.78
Global	**Total**	**876.34**	**10,606.99**	**17,963.51**	**5,738.17**	**0.26**	**2.49**	**4.52**	**0.25**	**0.00**	**665.33**

The data is provided by Newmont in its 2020 Sustainability Report (Newmont, 2021)

The land data given in Figure 7 by Polyus is particularly noteworthy as the land disclosures required by GRI in its sector specific disclosure G4 MM1 only cover land disturbed and rehabilitated, total and in the reporting year. This leaves out important information on whether the land disturbed and not rehabilitated is still being used by the company for its mining activities or not. It is vital to know this as it would indicate if the company fulfilled its responsibilities after mine closure. Polyus is providing this information through the data it gives on distribution of distributed and non-rehabilitated land.

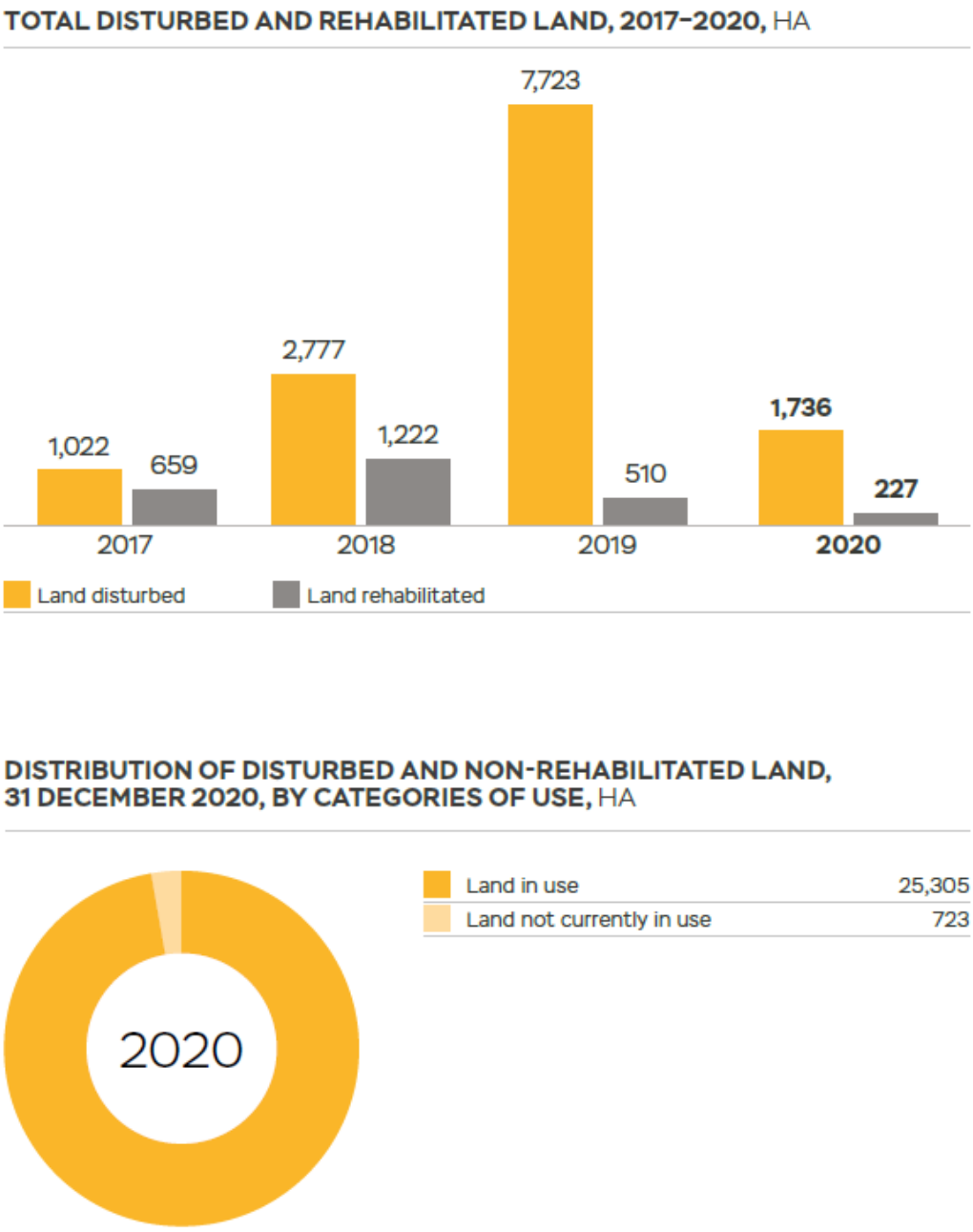

Figure 7. Land impact data by Polyus.

The data is provided by Polyus in its 2020 Sustainability Report (Polyus, 2022)

Next-Level Sustainability Performance Dashboard Disclosures

Table 22 is the proposed list of disclosures to be included in a next-level sustainability reporting dashboard for mining and metals corporations covering the identified significant impacts discussed in this thesis for sufficiency of information. Some of these disclosures are currently not included in GRI, SASB or ICMM frameworks and these are highlighted in bold. It would be critical to have the calculation methodology for each of the disclosures well-elucidated to ensure uniformity. By including several disclosures in ratios and percentages the dashboard aims for simplicity and comparability. By proposing that the information is available as the summary of the company's performance at the start of its sustainability report and in the highlights section of its sustainability webpages, it aims to enhance accessibility.

For enhancing credibility, I propose that all the disclosures (Table 22) should be third party verified at a reasonable or high level as defined by the accounting standards. For the sake of relevance for all stakeholders, the location (page no. of sustainability report or webpage link) of where the country / site level and total data is given should be provided in this summary itself. Local ecosystems such as water, land and air are significantly impacted by mining activities. This commonly affects the health of local communities as well as livelihoods of those engaged in sectors such as agriculture and animal husbandry and indigenous peoples dependent on natural resources. It is also important to bear in mind future risks from tailings dam failures on the surrounding communities. This makes it critical for local communities and members of civil society, who may or may not be well-versed with reading complex reports and data, to have

straightforward accessibility to site-level impacts and future risks associated with the mining activities being carried out in their vicinity by corporates.

Table 22. Proposed next-level sustainability performance dashboard disclosures.

No.	Sustainability Disclosure under four main categories	Unit	Indicate data location reference in sustainability report (page no. or URL)
Economic			
1	EVG&D same as per GRI template	Total numbers	Country level data
Environmental			
1	CO2eq emissions intensity in tons or kgs per unit mineral produced with **% primary data in LCA**	Ratio	**Total emissions split by country level**
2	**Water consumption intensity in m3 per unit mineral produced with % primary data in LCA**	Ratio	Total water consumed split by site level
3	Total incidents of non-compliance related with water	Total number	Site level data
4	**Mineral waste intensity in kg per unit mineral produced with % primary data in LCA**	Ratio	**Total waste split by site level**
5	Total no. and volume of significant incidents of spills and waste related accidents	Total number	Site level data
6	Total no. of tailings dams, total volume stored, total no. classified as high risk	Total numbers	Site level data
7	**Alignment with International Standard for Tailings Management across TSFs e.g., GISTM**	Yes or No	-
8	**Land in hectares where mining activity has closed and not rehabilitated in hectares and as % of total closed**	Total number and %	**Site level data**
9	Total no. of sites where Acid Rock Drainage took place and was mitigated / not mitigated	Total number	**Site level data**
10	**Air pollution intensity by pollutants in grams per unit mineral produced with % primary data in LCA**	Ratio	**Total pollution by pollutants split by site level**
Social			
1	No. of fatalities if any	Total number	**Country level data**
2	Total recordable injury frequency rate	Ratio	**Country level data**
3	Total occupational illness frequency rate	Ratio	**Country level data**
4	% of females in total workforce	%	**Country level data**
5	Total incidents of violations of human rights including rights of indigenous people	Total number	**Country level data**
6	% of workers with collective bargaining rights	%	**Country level data**
7	Total no. of strikes and lockdowns exceeding one week	Total number	**Country level data**

The disclosures highlighted in bold are currently not included in commonly used frameworks like GRI, SASB, ICMM

Chapter IV

Discussion

The demand for and extraction of metals and minerals is on the rise and this trajectory is not expected to change in the coming decades. There is increased focus on obtaining secondary or recycled material, but the growing demands from green energy infrastructure, rising aspirations for a higher quality of life, and increasing population in the developing world cannot be met from secondary material (UNEP, 2020a). Mining activities will continue to play a significant role in the world's economic activities. It is evident that high environmental and social costs are associated with mining and metals processing activities and actions to mitigate them need to be ramped up urgently.

It is argued that information on a company's environmental impacts is asymmetrically distributed between the company and local communities (Kulkarni, 2000). This is likely true not just for local communities but all the company's stakeholders, including consumers and investors. Informed actions from consumers, investors, employees, communities based on short- and long-term impacts require far wider transparency on environmental and social impacts of economic activities than available today. Transparency is vital for increasing market efficiency, and its power to release the collective wisdom of humanity to propel economic activity for the well-being of people and the planet in a just manner cannot be underestimated. Social scientists stress that being liked by fellow human beings and having a good reputation is of existential importance for most people. Jonathan Haidt in his book "The Righteous

Mind" elaborates how evolution has made the need to be liked by our fellow human beings an inherent part of being human (Haidt, 2012).

One can ask - does reputation matter to corporates as well? Does it matter that they look like they are doing the right thing? It certainly does; employees, consumers, investors all want to feel or at least be perceived as being associated with a company that is benefitting people and the planet. For a corporate to function effectively it is vital for it to have the social license to operate and is one of the main purposes of the wide-scale public relations exercises carried out by corporations. The next question is: Does sustainability reporting have a role in this? While it will not be a panacea, it can certainly be an important source for company information, akin to a company's financial reports for financial capital efficiency. This underscores the role of standardization of information and data on sustainability impacts as without that, corporates can quite easily subvert the principal of providing objective and honest information. This is being played out today with wide-scale accusations of green washing by companies.

Standardized sustainability reporting is missing today due to the voluntary nature of selecting disclosures, lack of standard practices on how sustainability reports will be presented, as well as loose calculation methodologies on impacts providing discretion to companies to "manage the data". As argued in this thesis, comparable, standardized sustainability disclosures between corporations that include disclosures scaled in terms of magnitude of economic activity, for example, GHG emissions per ton of metal produced, can catalyze positive impacts by giving the market a tool to reward high performers and penalize laggards. They could facilitate stakeholders to set benchmarks and make better choices on key issues such as sustainable purchase decisions by consumers and

sustainable investment decisions by investors. For local communities site level data such as total water consumed on site or air pollution emissions are the critical factors in granting “social license to operate”.

A Brief Critique of GRI and SASB Reporting Frameworks

The two commonly used frameworks in the mining and metals sector today are GRI and SASB. They have different priorities and focus areas. Another major influencer in sustainability reporting for large mining and metals corporations is the mining and metals industry association ICMM.

GRI’s focus is multi-stakeholder governance and public interest. It positions itself as a “catalyst for a sustainable world” and its core constituencies include business, civil society organization, investment institution, labor, and mediating institution (Global Reporting Initiative, 2022). Its lack of prioritizing site-level disclosures for civil society organizations representing local communities is therefore surprising. Another issue with GRI’s framework has been the discretion accorded to the companies to choose their material impacts and sustainability disclosures. As of today, a company stating that it is reporting as per GRI standards does not inform on what has been included in its reports. Additionally, even within reported disclosures it is commonplace for companies to pick and choose which metric to report and which to leave out, as shown in Tables 23, 24 and 25. This creates confusion, undermining GRI’s purpose of “providing organizations with the global common language to communicate their sustainability impacts” (Global Reporting Initiative, 2022). It appears GRI is recognizing the gaps in its reporting framework and changing its basic structure. Instead of having a core framework

supplemented with sector specific requirements, all future reporting will be required to be done on sector specific guidelines(Global Reporting Initiative, 2022).

Table 23. EVG&D data, BHP.

Country	Payments to governments US$M	Payments to suppliers[1] US$M	Payments to employees[1] US$M	Payments to shareholders, lenders and investors US$M	Social investment[1] US$M	Total economic contribution US$M	Profit/(loss) before taxation US$M	Number of employees/ contractors
Australia	9,373.5	8,289.7	3,367.7	4,540.7	74.6	25,646.2	20,824.2	45,295
Chile	1,396.7	3,263.6	666.9	146.6	20.2	5,494.0	5,650.6	23,372
United States	12.3	799.8	153.9	380.5	59.8	1,406.3	(1,406.5)	1,437
United Kingdom	12.2	41.7	15.5	3,084.5	0.4	3,154.3	113.0	59
Rest of the world	267.2	4,111.8	251.7	523.2	11.9	5,165.8	340.0	6,227
Total	**11,061.9**	**16,506.6**	**4,455.7**	**8,675.5**	**166.9**	**40,866.6**	**25,521.3**	**76,390**

The country-by-country data given in BHP's Economic Contribution report 2021 (BHP, 2021) does not include Revenue numbers as required by the GRI metrics

Table 24. Economic contribution in Botswana, Anglo American 2022.

The country-by-country data given in Anglo American Tax and Economic Contribution report does not include revenue and payments to capital providers as required by the GRI metrics (Anglo American, 2021)

Table 25. Significant environmental impacts, Freeport 2020.

FCX - ESG PERFORMANCE TREND DATA					
ENVIRONMENT	2016	2017	2018	2019	2020
Environmental Events					
Reportable spills or releases of hazardous or toxic chemicals[1,2]	33	25	17	33	19
NOVs related to permit exceedances, spills, releases or other compliance matters[3]	5	5	10	5	7
# of Significant Environmental Events (as defined on the Risk Register)	0	0	1	0	0
Cumulative environmental penalties ($ thousands)[4]	$0	$317	$0	$125	$67

The data on significant spills given by Freeport in its 2020 sustainability report (Freeport, 2021) includes data only on number of spills and not volume as required by GRI metrics

SASB's focus is financial materiality, and its objective is to "connect businesses and investors on the financial impacts of sustainability"; all its standards are industry specific (SASB, 2022). With limited number of disclosures required per industry and several metrics in percentages, e.g., renewable energy in total energy mix, and waste recycled, the SASB framework is easier to grasp. The problem with SASB standards is their narrow focus on financial materiality for investors, leading to key issues for other stakeholders being left out. For example, the metals and mining sector has no disclosure requirement on land impacts such as land disturbed and not rehabilitated, none on the distribution of economic value and does not require site-level disclosures under any topic. It would surely be a missed opportunity for sustainable and just development if the SASB disclosures were taken in their current form as the standard for sustainability requirement by market regulators. One could argue that sustainable and just development is not the mandate of market regulators. In that case another supra- international organization would have to create the disclosures required for this. That would lead to multiple

sustainability reporting requirements for corporations, adding to higher reporting burden on them. The best-case scenario would be that one framework that fulfils the main requirements of all stakeholders is adopted as the standard.

ICMM's focus is across all stakeholders, positioning itself as a "leadership organization working for a safe, just and sustainable world" (ICMM, 2022). It is incumbent on its members to report as per the GRI framework and obtain third party assurance. A noteworthy development is the release of ICMM's own Social and Economic Reporting – Framework and Guidance in May 2022 which includes key performance indicators on the corporations social and economic activities (ICMM1, 2022). ICMM's stated objectives for this include "providing a set of consistent indicators that gives stakeholders, such as investors, governments or local communities, comparable data to assess companies' contribution to social and economic development" and it expects its members to start reporting as per this framework from 2023, in their 2024 disclosures.

Conclusions

The reality is that the terminology of 'Sustainability' has become too wide, with no specific meaning of the term it has lost its value to communicate something precise. Encompassing several issues, it is no longer a word that can be used with clarity without further explanation. This has also metamorphosed into sustainability reporting by corporates, leading to different interpretations, which may be deliberate or not. This is detrimental to the cause of sustainability reporting and subsequently to sustainable development. It is also true that sustainability today encompasses several issues. Trying to narrow it down or simplifying it too much would lead to losing important value for

different stakeholders. This idea appears to have gained traction as there are sustainability frameworks under development by market regulators in Europe and USA (Kell & Cort, 2021).

This thesis built on the above ideas. By assessing the current reporting practices of the top 25 mining and metals corporates worldwide, this research identified current gaps and provided suggestions to close them. With credibility, sufficiency, and relevance as the foundation, it points to pathways for integrating simplicity, comparability, and accessibility in sustainability performance frameworks. For example, I recommend organizing disclosures better by starting all sustainability reports with a standard high-level sustainability performance dashboard, separating out performance in the reporting period from future strategies and plans to avoid any scope of waylaying the reader from current performance. A further improvement would involve changing the language of the disclosures from numbers that only experts can fathom to those scaled in terms of magnitude of business activity represented by ratios and percentages enabling comprehension and comparability of economic activities by a far wider population.

While this thesis was focused on sustainability performance disclosures it does not imply that information on the organization's future objectives and plans on sustainability topics is not important for key stakeholders, but stresses that current performance and future strategies need to be showcased separately for clear communication and to avoid any manipulation or greenwashing. Sustainability reports should include a standardized performance summary, toward the start of the report as most financial reports do and future strategies can be described within the report.

Sustainable development is a lofty endeavor of humanity that aims to improve quality of life while prioritizing equally all stakeholders, and spatial and temporal impacts. Undoubtedly the huge impetus in economic activities initiated by the industrial revolution has widely improved standards of living, but the edges of the current development model have begun to fray. This can be seen from widespread impacts like plastic pollution of oceans, deterioration in air quality, climate change impacts and leaching of toxic substances in our land and freshwater sources.

Quantitative metrics of sustainability have the power to transform vast amounts of unfathomable information about complex environmental and social topics into concise, policy-applicable, and decision-relevant information (Bose, Dong, & Simpson, 2019), and these must be brought into the service of sustainable development. Sustainability reports are one important source of information for civil society, corporate analysts, and media outlets on environmental and social impacts of corporates. It could well be argued that high-quality sustainability performance disclosures have a role to play in influencing a shift in the collective consciousness of humanity for steering economic activities towards a just, healthier, and safer future for people while preserving the inherent beauty and capacity of the earth to regenerate.

Appendix 1

Consolidated Evaluation of Company Sustainability Performance Transparency Index

Table 26. Transparency index for companies 1-7.

	Company	Glencore	BHP	Jiangxi Copper	Rio Tinto	Vale	Anglo American	Zijin Mining
	Country of HQ	Switzerland	Australia	China	UK / Australia	Brazil	UK / South Africa	China
Topic	**EVG&D**	0.33	0.67	0	0.33	0.33	0.67	0
Weightage	**5**	1.65	3.35	0	1.65	1.65	3.35	0
Topic	**GHG**	1	1	0.5	1	1	1	1
Weightage	**2**	2	2	1	2	2	2	2
Topic	**Air pollution**	0.5	0.5	0	0.5	0.5	0.5	0
Weightage	**1**	0.5	0.5	0	0.5	0.5	0.5	0
Topic	**Water**	0.8	1	0.4	0.6	0.6	0.4	0.6
Weightage	**3**	2.4	3	1.2	1.8	1.8	1.2	1.8
Topic	**Soild Waste**	0.75	0.5	0.25	0.75	0.5	0	0.5
Weightage	**2**	1.5	1	0.5	1.5	1	0	1
Topic	**Tailings Mgmt**	1	1	0	1	1	1	0
Weightage	**2**	2	2	0	2	2	2	0
Topic	**Land**	0.67	0.33	0	0.33	0.67	0.33	0.67
Weightage	**2**	1.34	0.66	0	0.66	1.34	0.66	1.34
Topic	**Labour relation**	1	1	0.5	0.5	1	1	0
Weightage	**1**	1	1	0.5	0.5	1	1	0
Topic	**Health& Safety**	1	1	0.67	1	0.67	1	0.67
Weightage	**3**	3	3	2.0	3	2.0	3	2.0
Topic	**Diversity**	1	1	1	1	1	1	1
Weightage	**1**	1	1	1	1	1	1	1
Topic	**3rd party assurance**	0.5	0.75	0	0.25	0.5	0.75	0.63
Weightage	**3**	1.5	2.25	0	0.75	1.5	2.25	1.89
	Total out of 20 / 25	17.89	19.76	6.21	15.36	15.8	16.96	11.04
	in %	72	79	25	61	63	68	44
	Company transparency ranking	6	3	21	10	9	8	19

Table 27. Transparency index for companies 8-14.

	Company	Fortesque	Nutrien	CMOC	Freeport	MMC Norilsk Nickel	Newmont Goldcorp	Southern Copper
	Country of HQ	Australia	Canada	China	Russia	USA	USA	USA
Topic	**EVG&D**	-	0	0	0.67	0	1	0
Weightage	**5**		0	0	3.35	0	5	0
Topic	**GHG**	0.5	0.5	1	1	1	1	0
Weightage	**2**	1	1	2	2	2	2	0
Topic	**Air pollution**	0.5	0.5	0	0.5	0.5	1	0
Weightage	**1**	0.5	0.5	0	0.5	0.5	1	0
Topic	**Water**	0.4	0.6	0.4	0.6	0.4	0.8	0.2
Weightage	**3**	1.2	1.8	1.2	1.8	1.2	2.4	0.6
Topic	**Soild Waste**	0.25	0.25	0.25	0.25	0.5	0.75	0
Weightage	**2**	0.5	0.5	0.5	0.5	1	1.5	0
Topic	**Tailings Mgmt**	1	0	0	1	0.5	1	0
Weightage	**2**	2	0	0	2	1	2	0
Topic	**Land**	0.33	0	0	0.67	0.67	1	0
Weightage	**2**	0.66	0	0	1.34	1.34	2	0
Topic	**Labour relation**	0.5	0.5	0.5	1	1	1	0
Weightage	**1**	0.5	0.5	0.5	1	1	1	0
Topic	**Health& Safety**	1	0.67	0.67	0.67	1	1	0.67
Weightage	**3**	3	2.0	2.0	2.0	3	3	2.0
Topic	**Diversity**	1	1	1	1	1	1	0
Weightage	**1**	1	1	1	1	1	1	0
Topic	**3rd party assurance**	0.25	0.5	0.5	0.75	0.5	0.5	0
Weightage	**3**	0.75	1.5	1.5	2.25	1.5	1.5	0
	Total out of 20 / 25	11.11	8.81	8.71	17.75	13.54	22.4	2.61
	in %	56	35	35	71	54	90	10
	Company transparency ranking	13	20	20	7	16	1	25

Table 28. Transparency index for companies 15-20.

	Company	Barrick Gold	Shandong Gold Mining	The Mosaic Company	Anglo American Platinum	Sumitomo Metal Mining	Teck
	Country of HQ	Canada	China	USA	South Africa	Japan	Canada
Topic	**EVG&D**	0	0	0.33	0.33	0.33	1
Weightage	**5**	0	0	1.65	1.65	1.65	5
Topic	**GHG**	1	0.5	0.5	0.5	1	1
Weightage	**2**	2	1	1	1	2	2
Topic	**Air pollution**	0	0.5	0.5	0.5	0.5	0.5
Weightage	**1**	0	0.5	0.5	0.5	0.5	0.5
Topic	**Water**	0.4	0.2	0.4	0.4	0.4	1
Weightage	**3**	1.2	0.6	1.2	1.2	1.2	3
Topic	**Soild Waste**	0.5	0.5	0.75	0.5	0.25	0.5
Weightage	**2**	1	1	1.5	1	0.5	1
Topic	**Tailings Mgmt**	1	0	0	1	0.5	1
Weightage	**2**	2	0	0	2	1	2
Topic	**Land**	0.67	0	0.67	0.33	0.67	0.67
Weightage	**2**	1.34	0	1.34	0.66	1.34	1.34
Topic	**Labour relation**	0.5	0	1	0	0	1
Weightage	**1**	0.5	0	1	0	0	1
Topic	**Health& Safety**	0.67	0.33	1	1	1	1
Weightage	**3**	2.0	1.0	3	3	3	3
Topic	**Diversity**	1	1	1	1	1	1
Weightage	**1**	1	1	1	1	1	1
Topic	**3rd party assurance**	0.75	0	0.5	0.75	0.5	0.5
Weightage	**3**	2.25	0	1.5	2.25	1.5	1.5
	Total out of 20 / 25	13.3	5.09	13.69	14.26	13.69	21.34
	in %	53	20	55	57	55	85
	Company transparency ranking	17	24	14	12	14	2

Table 29. Transparency index for companies 21-25.

	Company	South32	KGHM	First Quantum Minerals	Antofagasta plc	Polyus
	Country of HQ	Australia	Poland	Canada	Chile[(1)]	Russia
Topic	**EVG&D**	0.33	0.33	0.33		
Weightage	**5**	1.65	1.65	1.65		
Topic	**GHG**	1	1	1	1	1
Weightage	**2**	2	2	2	2	2
Topic	**Air pollution**	0.5	0	1	0	0.5
Weightage	**1**	0.5	0	1	0	0.5
Topic	**Water**	1	0.2	0.8	0.6	0.6
Weightage	**3**	3	0.6	2.4	1.8	1.8
Topic	**Soild Waste**	0.5	0.5	0.25	0.25	0.5
Weightage	**2**	1	1	0.5	0.5	1
Topic	**Tailings Mgmt**	1	0.5	0.5	0.5	1
Weightage	**2**	2	1	1	1	2
Topic	**Land**	0.67	0	0.67	0	0.67
Weightage	**2**	1.34	0	1.34	0	1.34
Topic	**Labour relation**	1	0.5	0	1	0.5
Weightage	**1**	1	0.5	0	1	0.5
Topic	**Health& Safety**	1	0.67	0.67	1	1
Weightage	**3**	3	2.0	2.0	3	3
Topic	**Diversity**	1	0	1	1	1
Weightage	**1**	1	0	1	1	1
Topic	**3rd party assurance**	0.75	0	0	0.5	0.5
Weightage	**3**	2.25	0	0	1.5	1.5
	Total out of 20 / 25	18.74	8.76	12.9	11.8	14.64
	in %	75	35	52	59	73
	Company transparency ranking	4	20	18	11	5

Appendix 2

List of Company Sustainability Reports and Information Sources

Glencore

- 2020 Sustainability Report
- 2020 Glencore ESG Data Book and GRI Index including SASB References
- 2020 Payments to Governments
- Glencore Tailings Management

BHP

- BHP Annual report 2021 (June 2020 to June 2021)
- ESG Standards and Data Book 2021
- BHP Tailings Storage Facility Management Update 2021
- Economic Contribution Report

Jiangxi Copper

- Jiangxi Copper 2019 ESG report

Rio Tinto

- Sustainability Factbook 2020
- Taxes paid report 2020
- Sustainability approach
- Tailings report

Vale

- Vale Integrated Report 2020 and ESG Data Book 2020
- Vale tax transparency report

Vale on disclosure of tailings dams'

Anglo American

Integrated report 2020

Sustainability report 2020

Tax and Economic Contributions report 2020

Tailings database

Zijin

Zijin Mining group 2020 ESG report

Fortescue

Sustainability report 2021

Annual report 2021

Nutrien

ESG report 2021

2021 KPMG Independent Limited Assurance report

Tailings Safety Disclosure

CMOC

ESG report 2020

MMC Norilsk Nickel

Sustainability report 2020

Freeport McMoRan

Sustainability Report 2020

ESG data 2020

Tailings disclosure report

Newmont Goldcorp

- 2020 Sustainability Report
- 2020 Sustainability Report Assurance Statement
- 2020 ESG Data
- Tailings Management

Southern Copper

- Annual Report 2020

Barrick Gold

- Sustainability Report 2020
- Tailings Management

Shandong Gold Mining

- Shandong Gold Annual and Sustainability Report 2020

The Mosaic Company

- Sustainability Disclosure and GRI Index 2020
- 2020 ESG Performance Summary
- Tailings disclosures

Anglo American Platinum

- Integrated Annual Report 2020
- Sustainability Report 2020
- Tailings disclosures
- Tax and Economic Contributions Report

Sumitomo Metal Mining

Integrated Report 2020

Teck

Sustainability Report 2020

Economic Contributions Report 2020

Tailings Management

https://www.teck.com/sustainability/sustainability-topics/tailings-management/

South 32

Sustainable Development Report 2020

Tax Transparency and Payments to Governments Repot

Waste and Tailings

KGHM PMSA

KGHM Integrated Report 2020

First Quantum

ESG 2020 Data

Tax Transparency Report 2020

Antofagasta PLC

Antofagasta Sustainability Report 2020

Polyus

Polyus Sustainability Report 2020

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