IGF INTERGOVERNMENTAL FORUM
on Mining, Minerals, Metals and
Sustainable Development

Women and the
Mine of the Future

Global Report

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The Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF) supports its 80 member countries in advancing their sustainable development goals through effective laws, policies, and regulations for the mining sector. We help governments take action to develop inclusive and gender-equitable practices, optimize financial benefits, support livelihoods, and safeguard the environment. Our work covers the full mining life cycle, from exploration to mine closure, and projects of all sizes, from artisanal mining to large-scale operations. Guided by our members' needs, we provide in-country assessments, capacity building, technical training, publications, and events to advance best practices, peer learning, and engagement with industry and civil society.

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April 2023

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Abbreviations

CET	community education and training
CMEWA	Chamber of Minerals and Energy of Western Australia
ESG	environmental, social, and governance
GHG	greenhouse gas
ICMM	International Council of Metals and Mining
ICT	information communications and technology
IGF	Intergovernmental Forum on Mining, Minerals, Metals, and Sustainable Development
ILO	International Labour Organization
IoT	Internet of Things
ISCED	International Standard Classification of Education
ISCO	International Standard Classification of Occupations
ISIC	International Standard Industrial Classification
IWiM	International Women in Mining
FIFO	fly-in fly-out
IT	information technology
LFS	Labour Force Surveys
MCI	Mineral Contribution Index
OECD	Organisation for Economic Co-operation and Development
PPE	personal protective equipment
RMI	Responsible Mining Index
SDGs	Sustainable Development Goals
STEM	Science, Technology, Engineering, and Math
TVET	Technical Vocational Education and Training
UNDP	United Nations Development Programme
VET	vocational education and training
WEF	World Economic Forum
WMF	Women and the Mine of the Future

Introduction

Background and Rationale of the Women and the Mine of the Future Project

The large-scale mining sector is facing fundamental structural changes resulting from global megatrends. These include rapid technological advances and the rising demand for minerals and metals caused by the energy and digital transitions, as well as growing pressure from investors, civil societies, and consumers to mine more responsibly and equitably. Growing awareness of the contributions of mining toward a range of Sustainable Development Goals (SDGs), such as economic growth, employment, and development impacts, is also a driving force for inclusive, safe, and responsible mining.

FIGURE 1. The forces shaping the future of mining

Source: Authors' diagram.

Compounded by each other—and recently accentuated by the COVID-19 pandemic—those forces will fundamentally alter the way the mining sector operates. This will have significant implications for mining governance, business models, organizational structures, work environments, and operations of mining enterprises, as well as for policy-makers, employers, workers, their families, and communities.

The pace and breadth of those changes will inherently be country—and context—specific. They will have significant implications for the labour market and for local supply chains, with potentially deeper impacts for mining communities. Because the mining sector is currently male dominated, those changes are expected to impact men and women differently. To better understand those impacts and the opportunities they offer for women, the current state of play of the representation of women in the mining workforce needs to be thoroughly analyzed.

Regrettably, there is a dearth of consistent, detailed, and comparable data sets and in-depth analysis regarding the status of employment, by gender, in the large-scale mining sector. Additionally, there is insufficient systemic assessment of women's direct participation in mining operations by occupation, level of education, and skills by country, let alone their working conditions and salaries. This lack of consistent and detailed data on gender equality in mining employment is even more pronounced when data is sought regarding indirect employment along the mining supply chain. There are no reliable estimates of the number of women that are indirectly employed in mining supply chains, such as in businesses that supply goods and services to the mining sector, and even less information about their conditions of work.

The lack of a reliable baseline regarding the working conditions of women and men in large-scale mining is preventing any meaningful policy reforms and investments in gender equality and a more inclusive and diverse mining workforce. In particular, the rapid technological changes and rising demand for minerals needed for the low-carbon and energy transitions will have sweeping effects on the mining labour force. The data challenges today, however, render any forecasts about the changing nature of occupations and related skills needs for the large-scale mining sector, its suppliers, and host communities weak and speculative. Since policy-makers are concerned about future skills needs, and large-scale mining companies are already competing for global talent, they need more and better data and information about the barriers and potential for attracting more women to work in the mines of the future.

If the large-scale mining sector is to become more inclusive and contribute to the achievement of the 2030 Agenda for Sustainable Development—specifically of SDG 5 on gender equality and the empowerment of women and girls and SDG 8 on inclusive growth and decent work—it is necessary to address these data and analytical gaps, support countries with tools and guidance to navigate the transition toward the mine of the future, and provide dedicated policy support to all stakeholders likely to be impacted.

Project Design

This global report is part of the Women and the Mine of the Future (WMF) Project, which has three phases.

Phase I, which is the subject of this global report, establishes a baseline for a sample of 12 countries to uncover the existing gender-disaggregated profile of workers in large-

scale mining,[1] with particular attention being paid to the participation of women and the occupations in which they work.

Phase II will seek to understand the potential impacts of technological advances and the rising demand for minerals for the low-carbon and energy transitions in terms of the skills needed for the future of mining. Skills anticipation studies will be carried out in a limited number of countries, with a specific focus on opportunities and challenges for women in the mines of the future.

Phase III will explore the potential impacts that technological advancements, higher demands for minerals, and responsible mining requirements will have on women along the mining supply chains. This phase will focus on upstream opportunities, notably through mining procurement, and, where possible, on indirect downstream opportunities.

Through the implementation of these consecutive phases, the project will provide a set of practical policy tools and recommendations for governments, mining companies, and representatives of mineworkers and other key stakeholders to address the barriers faced by women in mining and to advance gender equality in the mine of the future. Those recommendations will aim to:

- Improve gender-disaggregated data collection and analysis on changing mining occupations, skills, and job profiles.
- Overcome challenges faced by women to access current and future employment in decent conditions of work in the large-scale mining sector.
- Support women employed in mining and women living in mining communities to have access to better job opportunities in the mining sector and in supply chains.
- Provide guidance on ways and means to empower and support women in their career paths, while fighting stereotypes, bias, working conditions, or discrimination that may hinder their advancement in the sector.

Selected Countries

This global report is based on data collected from a sample of 12 countries: Argentina, Australia, Brazil, Canada, Chile, Colombia, Ghana, Mongolia, Peru, South Africa, Sweden, and Zambia. The countries were carefully selected from a set of criteria that take into account different levels of development and a balance in their geographical location. One of the key selection criteria was the availability of reliable and updated national statistics, such as data produced in Labour Force and Household Surveys, as well as other data collected at the national and regional levels, and preferably reviewed, validated, and published by the International Labour Organization (ILO). Other secondary criteria considered were membership in the IGF, the presence of Women in Mining organizations, and Extractive Industries Transparency Initiative-implementing countries with the presence of multistakeholder groups. The existence of a gender policy in the mining sector was also considered.

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1 Demographic data collected at the national level are usually based on sex as opposed to gender, and as a result do not capture gender identity and diversity within the mining industry. This means that gender-diverse individuals such as trans people and non-binary people are not captured by the data, and neither are the social reality and norms that affect how they are perceived and treated in the workplace. For this reason, the analyses in the country reports—and, as a result, the global report—very much remain divided along the female-male and women-men sex and gender binary.

Project Methodology for Phase I

This global report is a cross-country analysis of the major trends in women's participation in the large-scale mining labour force. It is based on the findings gathered from baseline studies of the 12 countries selected. These baseline studies were designed to gather gender-specific data from countries with different socio-economic contexts. For each country report, researchers used official national statistics to allow cross-country comparison. The global report also draws on data from the ILO (see Figure 2).

Of the 12 countries selected for the project, the global report is based on the completed final reports from Australia, Brazil, Canada, Chile, Ghana, Mongolia, Peru, South Africa, and Sweden. Preliminary findings for Argentina were considered. At the time of the drafting of this report, the final country reports from Colombia and Zambia are still being produced, and their findings will be contrasted with the trends and challenges identified in the present document at a later stage. Detailed data and statistics from the ILOSTAT database were available for all countries and were considered for this report, with the exception of mining data for Canada, Australia, and Argentina, which was unavailable. For more information on the detailed methodology as well as limitations, please refer to the Methodological Note in Appendix A.

FIGURE 2. Summary of project methodology

Gender-disaggregated country data profiles as collected by the ILO, in particular household surveys and labour force surveys, and through National Statistics Bureaus.

Country reports that provided country-specific diagnosis of policies and data related to employment, education levels, age, skills, gender pay gap and other critical profiles of women and men in the large-scale mining sector.

Global Report Phase I

For more information on the detailed methodology as well as limitations, please refer to the Methodological Note in Appendix A. Specific data challenges and limitations are discussed in detail in Chapter 3.

Purpose of the Global Report

The first phase of the WMF project aims at ascertaining the gender-disaggregated profiles of workers in the large-scale mining sector in 12 countries. Historical data is essential to help policy-makers, corporate leaders, and women workers (and their organizations) ask the right questions and is essential for better-informed policies to advance women's participation in the mining sector. In that regard, this global report highlights, in a comparative way, the main data findings from the country reports as well as global trends observed across countries that can be drawn from ILO data.

TABLE 1. Summary of the dos and don'ts of this global report

What this global report DOES NOT do	What this global report DOES
The report does not include the participation of women in the artisanal and small-scale mining sector and does not include data from oil and gas.	The report considers the participation of women in large-scale mining only. The definition of "mining" is the one used in the International Standards for Industry Classification (ISIC) as defined by the United Nations.
This report does not provide a diagnostic for the underrepresentation of women in the mining workforce.	Phase I of the WMF project provides a snapshot of the profile of workers in the large-scale mining sector. It is a data analysis report that establishes a baseline for the participation of women in the mining workforce based on data from 12 countries.
The report does not make projections about the extent to which the future of mining will be more inclusive for women or not.	The second phase of the project will analyze the changes in the sector and forecast the opportunities the sector will offer (and the skills needed) in the future and will therefore provide recommendations for the future representation of women in the mining workforce.
This report does not cover women's representation in mining supply chains.	This phase of the WMF project focuses on direct employment only. The third phase will focus on the supply chains.
The report does not analyze the reasons and root causes of the gender divide in the sector.	Where relevant, the existing literature and findings from the qualitative sections of country reports are utilized to provide context for some trends observed across countries. This is a complement to the report, not the overall objective.

What this global report DOES NOT do	What this global report DOES
The analysis of the data provided in this report should not be interpreted to make generalizations that would apply to all mineral-producing countries in the same way.	While the selection of the countries was done in a way to ensure global representation, a sample of 12 countries is not sufficient to draw general conclusions on gender equality in mining. Similarly, the limited data availability in some countries does not allow us to generalize the findings across countries with similar levels of development. Instead, the report brings together main trends and, where relevant, showcases some particularities to underscore nuances.
The data included in the report is not consistently inclusive in terms of gender disaggregation.	The data collected and represented in national statistics are disaggregated by sex and are not sensitive to measuring trans or non-binary persons. In cases where intersectional disaggregation was available (i.e., by race, ethnicity, and Indigeneity) these findings were presented and analyzed. These, however, remain country specific.

Structure of the Global Report

The first chapter contrasts the data findings from the ILO and from country baseline studies against a set of commonly held assumptions about the large-scale mining sector, which are explored in more depth in the literature review in Appendix B. While the data from the ILOSTAT database is used to enable comparison across different countries, the findings of the country baseline studies offer more granular data and explore nuances and country particularities, which are then analyzed against each assumption.

Chapter 2 is forward looking and outlines global trends for the future of large-scale mining, namely the deployment of disruptive technologies as well as the need to adapt to the impacts of climate change and to the rising demand for minerals for the energy transition to the low-carbon future. It relies on previous IGF research and a review of available literature, and it looks at the consequences those global forces may have on mining occupations. This chapter relies on the findings of the ILO data and country reports to map out the gender dimensions of a changing mining industry.

Chapter 3 identifies the main data gaps and challenges that need to be addressed to enable evidence-based policy-making and open opportunities for women to participate in the future of mining.

Chapter 4 offers an overview of policy recommendations for governments, companies, and workers to consider.

A detailed methodological note, a review of existing literature on large-scale mining, and a summary table of maternity leave policies for the country studies and a sample of mining companies can be found in the appendices.

1.0 Deep Dive in Trends in Women's Participation in the Mining Workforce

This chapter analyzes the gender-disaggregated data gathered during the first phase of the WMF Project, profiling the women working in the large-scale mining sector.[2] The objective is to highlight, in a comparative way and based on country case studies and ILO data from 12 selected countries, the assumptions and trends around women's participation and working conditions in large-scale mining, exploring the challenges that female workers face in specific jurisdictions and globally.

While the data gathered confirm that female workers are globally underrepresented in large-scale mining activities, it also highlights that many countries are experiencing a gradual increase—albeit at a very slow pace—in the number of women in the large-scale mining labour force. This is a promising sign that the dynamics that historically prevailed in the sector are improving. However, the report also shows that it is not yet possible to talk about a true integration of women in the mining workforce. The relative increase in the number of women employed in mining is not synonymous with increased gender equality either. Structural barriers, biases, and discriminatory practices and working conditions impeding women's empowerment still largely prevail and need to be concurrently and duly addressed.

Assumption 1: The large-scale mining sector is a small employer compared to other economic sectors.

Large-scale mining is capital intensive, and the sector is therefore a small direct employer at the national level. Indirect employment—linked to supply chain activities and induced employment created through economic support sectors around mine sites—is more significant.[3] This assumption generally holds true in the countries studied for this project. However, as the trends below highlight, there are some important nuances that merit particular attention.

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2 For the purposes of this project, the term "mining sector" also includes "quarrying" activities, considering that the data provided by some countries encompassed both activities.
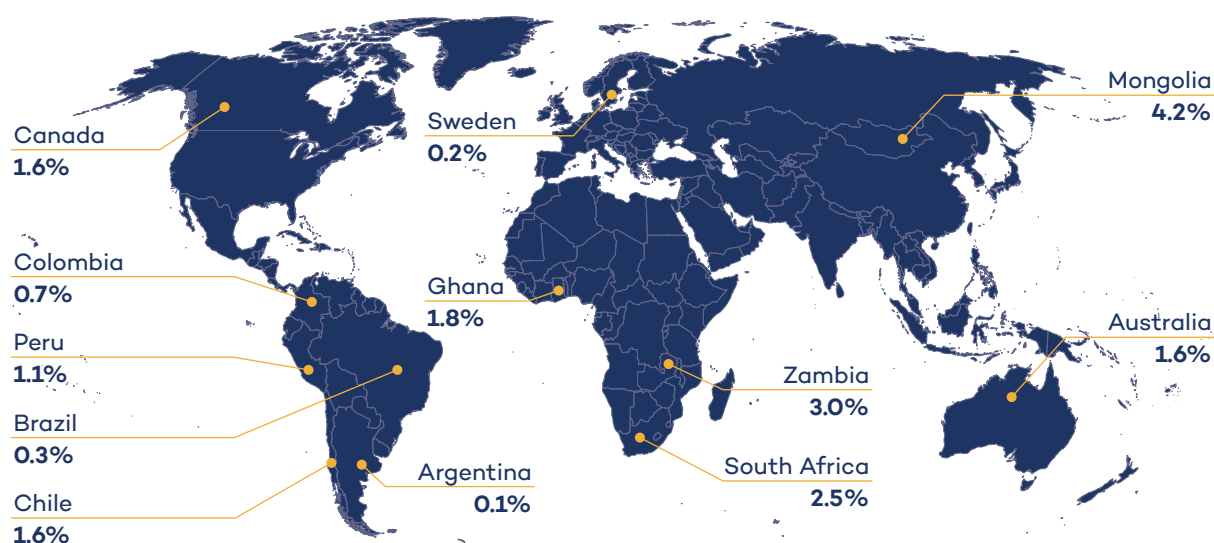
3 Gendered analysis of indirect and induced employment falls outside the scope of this study. The IGF intends to dedicate another phase of this project to analyze those job opportunities and how they impact female labour force.

Trend 1: Large-scale mining is indeed a small direct employer.

Figure 3 shows the share of workers employed in the large-scale mining sector across 12 countries. Large-scale mining in Mongolia has the highest employment rate (IGF, 2022f), with 4.2% of total employment. Argentina and Sweden have the smallest share, with large-scale mining accounting for only 0.1% and 0.2% of total employment, respectively. The share of direct employment in large-scale mining reflects the structure of the economies and the size of the mining sector, compared to other economic activities. In more diversified economies like Brazil and Sweden, the share of direct employment in large-scale mining is smaller. Similarly, in countries that have a large mining sector, such as in South Africa, or in Mongolia, the share of direct employment is higher.

FIGURE 3. Share of workers engaged in large-scale mining and quarrying sector (%)

Canada
1.6%

Sweden
0.2%

Mongolia
4.2%

Colombia
0.7%

Ghana
1.8%

Australia
1.6%

Peru
1.1%

Zambia
3.0%

Brazil
0.3%

Chile
1.6%

Argentina
0.1%

South Africa
2.5%

Source: Authors' calculations, based on ILO database, 2018, except Australia, ILO database, 2016 (IGF, 2022a); Chile (IGF, 2022d), and Ghana ILO database, 2017 (IGF, 2022e). Data from Canada are from national statistics, 2021 (IGF, 2022c).

As highlighted in Trend 3 below, it is important to note that mining employment is highly cyclical in line with the boom-and-bust cycles of the mining industry. These cycles can have significant impacts on the industry and on its workers as well as for investors, enterprises in mining supply chains, and local mining communities. For instance, a sharp drop in demand for minerals during downcycles can have a negative impact on prices and revenues, which in turn may force mining companies to reduce operations and spending. This impact will have ripple effects throughout mining supply chains, with fewer opportunities for suppliers of goods and services, and a loss of jobs and livelihoods in the industry itself and in mining communities. Women tend to be more impacted than men, as shown under Assumption 2, Trend 3 (below).

Trend 2: Mining is a small employer at national level but is otherwise a key economic sector.

Despite its relatively small share of employment at the national level, the sector is nonetheless significantly important to the national economy in many countries.

TABLE 2. Economic contribution of large-scale mining, 2020

	International Council of Metals and Mining (ICMM) Mining Contribution Index (MCI) Ranking	ICMM MCI Index	Mineral exports contribution, 2020	Change in mineral export contribution (2015–2020)	Mineral production value as a % of GDP, 2020	Mineral rents as a % of GDP, 2020	Previous ICMM MCI ranking
Mongolia	2	96	90.9	8.75 pp*	23	21.27	3
Zambia	7	93.1	79.5	6.57 pp	36.02	9.71	4
Chile	13	88.2	58.2	4.49 pp	17.73	6.12	27
Australia	15	88	59.6	6.12 pp	9.11	8.16	36
South Africa	17	86.4	45.5	8.99 pp	9.68	2.95	37
Peru	20	84.8	60.2	2.54 pp	11.91	3.94	11
Brazil	30	77.7	18.6	5.09 pp	2.65	3.09	52
Ghana	32	75.2	41.4	0.10 pp	6.01	8.17	15
Colombia	34	74.3	24.2	6.88 pp	0.59	0.89	19
Canada	42	71.2	13.2	2.23 pp	2.21	0.97	50
Sweden	54	60.9	5.6	1.16 pp	0.74	0.64	64
Argentina	93	42.6	2.2	-4.58 pp	0.73	0.69	82

Source: ICMM, 2022.

*Note: *pp refers to percentage points.*

The International Monetary Fund considers countries to be "resource rich" when exports of non-renewable natural resources, such as minerals and metals and hydrocarbons, account for more than 25% of the value of the country's total exports (International Monetary Fund, 2013).

In 2014, McKinsey Global Institute used a broader set of criteria to highlight the important of the mining sector to resource-rich countries. Three criteria were used: (i) mineral exports represent more than 20% of total exports (ii) resource revenues account for over 20% of government revenue; and/or (iii) the share of resource rents to GDP is higher than 10%.

ICMM has used a similar set of criteria to underscore the importance of the mining sector in national economies, building an MCI every 2 years to show the significance of the economic contribution of mining and metals to national economies. The latest edition of the ICMM MCI (2022) confirms the fact that mining is an important economic contributor. The index looks at the significance of mining contributions to national economies by synthesizing four indicators, as shown in Table 2. It ranks Mongolia, Zambia, Chile, Australia, South Africa, and Peru in the

top 25 countries (with a ranking above 80, highlighted in green in Table 2) where mining has the most contributions in their national economies in 2020. The lowest-ranking country on the ICMM MCI was Argentina (in orange), ranking 93 out of 183 countries.

Table 2 summarizes the four key indicators that are recognized as proxies for the economic contribution of the mining sector to the economy. In 2020, in 9 of our 12 baseline countries, mineral exports contributed to more than 20% of total merchandise exports, and hence to foreign exchange earnings. In five out of the nine countries, that share was even greater than 50%, showing the critical importance of the mining sector compared to other productive sectors.

Table 2 also highlights the value of mineral production expressed as a share of GDP, a measure that points to the value of mineral production at mine sites, relative to GDP. The higher that percentage, the more value is produced in the country.[4] Among our baseline countries, Zambia and Mongolia particularly stand out, with a mineral contribution of 36% and 23% respectively, showing the dominant role of mining in national wealth creation. All but one country (Argentina) saw their mineral production increase in the past 5 years, as shown by the change in mineral export contribution indicator, aimed at measuring how the mining sector evolved over a 5-year period.

Mineral rents, which are the estimated difference between the value of mineral production at world price and their average cost of production, indicate the contribution of mineral extraction to the economy. Table 2 shows that mineral rent is very significant in Mongolia (21.27% of GDP), and important in Zambia (9.71%), Ghana (8.17%), and Australia (8.16%).

While a high score on the MCI (the closer a country is to 100, the higher it ranks) is a good proxy for the economic importance of the sector, it is not, however, a sufficient indicator of socio-economic, governance, or environmental progress, which are dependent on other factors such as good governance, good business practices, accountability and transparency, and sound management of mineral resources, amongst others (ICMM, 2022).

The mining sector represents a significant source of inward foreign direct investment. The exploration and production phases are the most investment-intensive phases, as large-scale mining is highly capital intensive. It should be said that investment levels are prone to high volatility. They are notably responsive to the demand for specific minerals and metals and to the business climate in producing countries. However, data are difficult to obtain at the global level.

Trend 3: While mining is a small employer, it is highly important for local communities.

Despite its small share in national employment, large-scale mining is often the largest, if not the only, formal employer for local communities living around mining activities. The sector offers significant direct and indirect mining jobs, particularly for women living in mining communities. While most country reports do not have specific data on local direct and indirect employment, some reports contained data on employment of Indigenous People, which provided insights into the importance of mining for people employed locally.

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4 Note that this indicator does not represent the contribution of mining to GDP—on average perhaps only a third of production value represents value addition to the national economy.

In Ghana, data based on the 2020 Ghana Chamber of Mines show that 27% of all Ghanaians directly employed in large-scale mining were employed within their locality. In addition, 27% of the Ghanaian female workforce was also employed in their locality.

In Canada, where data on the employment of Indigenous populations are available, Indigenous People represented 10% of the mining workforce in 2021. Indigenous women made up 17% of all Indigenous People employed. In Australia, the majority of mining employment is in Western Australia and Queensland, the two states where mining most often occurs. In 2016, women made up 19% of the Indigenous workforce, a slightly higher percentage than the non-Indigenous workforce. That proportion increases to 24% for the Aboriginal and Torres Strait Islander workforce. This high proportion of Indigenous women in the mining workforce in Australia can be partly explained by dedicated government and company initiatives to increase employment opportunities for Indigenous populations in Australia.[5]

Overall, women's employment in the mining sector is critical for the economic empowerment of women in local communities where mining operations take place. This is of particular importance when and where other employment opportunities are scarce and the sector offers higher wages compared to other sectors (See Assumption 5 for further details on wages).

Assumption 2: Large-scale mining is a highly masculinized sector.

A significant share of employment in the large-scale mining sector is held by men. According to ILO modelled estimates (ILO, 2021), some 21.4 million workers are employed globally in mining, of which an estimated 85% are men. This is largely confirmed by all countries in the baseline studies. The following trends provide a more granular analysis of gendered employment and the extent to which the sector has been able to address the gap.

Trend 1: Large-scale mining is indeed one of the most masculinized economic sectors.

The findings from seven of the 12 baseline country reports all confirmed that the large-scale mining sector is characterized by an extremely low female participation rate when compared to other economic sectors.

Looking at sectoral employment at the national level, women are least employed in mining and construction, and mostly employed in health care services and education and training. Peru, Canada, and Sweden (IGF, 2022c, 2022g, 2022i), had the largest concentration of female employees in the health sector, while Sweden, Mongolia, and Australia (IGF, 2022a, 2022f, 2022i) have more women employed in education and training. One notable observation is Mongolia's relatively high representation of women in both manufacturing and financial services.

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5 In this regard, the ILO Indigenous and Tribal Peoples Convention, 1989 (No. 169), which has been ratified by many mining countries, calls on governments to ensure "that workers belonging to these peoples enjoy equal opportunities and equal treatment in employment for men and women, and protection from sexual harassment."

FIGURE 4. Percentage of women employed in mining vs. other sectors (%)
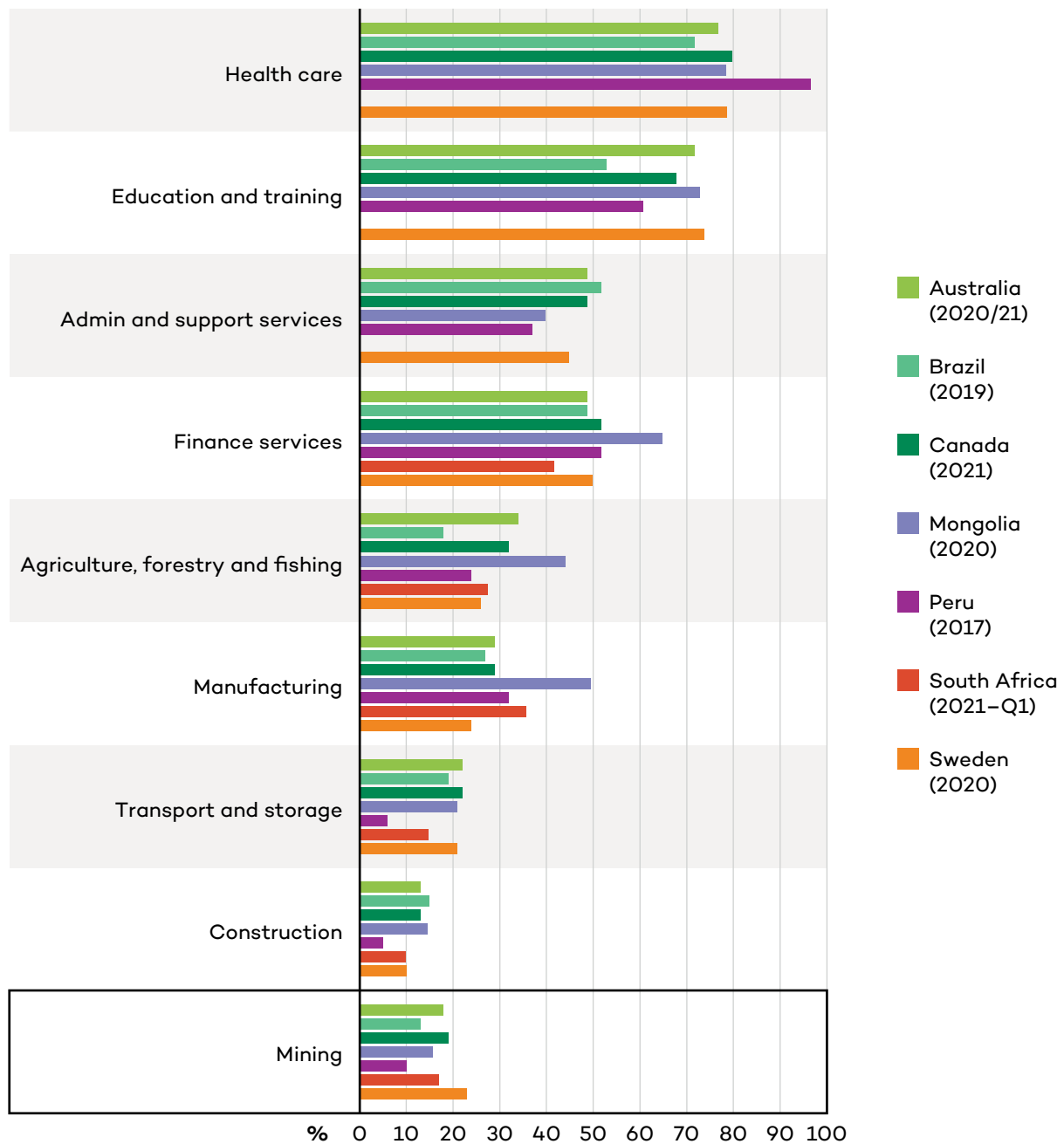
Source: Authors' calculations, based on ILO database.

Zooming into mining as an economic sector, ILO data in Figure 5 show that Sweden registered the highest share of female participation in total mining employment, with 25%. In other countries, women accounted for 9% to 19% of mining jobs, showing an evident underrepresentation of women across the board.

A closer look at Figure 5 shows that Peru (2018) had the lowest female participation rate, recording only 9% of women employed in the mining industry. Brazil, Chile, and Argentina demonstrated a similar trend, with 10% of female employees. In Chile, this percentage is one of the lowest among the Organisation for Economic Co-operation and Development (OECD), despite the country's higher levels of economic development and female education.

FIGURE 5. Gender distribution in large-scale mining (%)
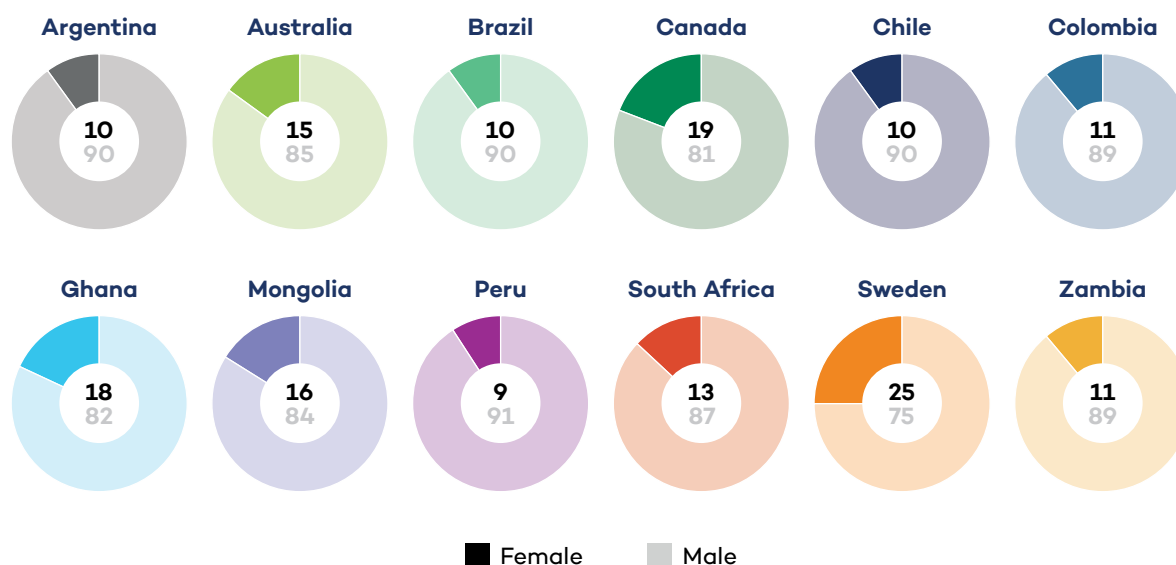
Source: Authors' calculations, based on ILO database, 2018, except Australia, ILO database, 2016 (IGF, 2022a); Chile (IGF, 2022d) and Ghana, ILO database, 2017 (IGF, 2022e). Data from Canada is from national statistics, 2021 (IGF, 2022c); data from Argentina is from Sistema de Informacion Abierta a la Comunidad sobre la Actividad Minera, 2021.

HIGHLIGHT #1: SEXIST BIASES MAY BE KEEPING WOMEN OUTSIDE LARGE-SCALE MINING EMPLOYMENT.

In many Latin American countries, baseline reports highlighted the presence of sexist biases as an obstacle to women's entry into the mining workforce. In Peru (IGF, 2022g), bias studies found the prevalence of machismo attitudes and gendered division of labour both at work and at home are real and persistent challenges facing women in the workplace. The sexist biases contribute to unequal treatment in hiring, promotions, and salary remuneration, based on erroneous inferences by employers about the productivity of workers based on their gender. Large-scale mining also falls short when it comes to retaining female workers after childbirth, which may explain the low proportion of women in the sector. It was also found that women were more likely to be absent or to withdraw from work than men when faced with adverse situations. This has negative impacts on the accumulation of experience for women.

Women interviewed as part of the Brazilian baseline study shared similar experiences of sexist attitudes. The expectation that women were going to quit their own jobs to accompany their husbands was cited as a barrier to women accessing mining jobs, especially in remote settings. Unconscious bias undermining women in positions of authority or leadership was also raised as being common. Similarly to the Peru report, unconscious bias was also raised as part of the Argentina baseline report as a reason why women are disproportionately expected to carry out unpaid work, which can limit their entry into the workforce. The mining culture was also characterized as heavily masculinized, holding many prejudices against women's participation.

Cultural factors are considered potential reasons contributing to this imbalance in the participation of women in a country's workforce. According to the Chilean study (IGF, 2022d), the more discriminatory the cultural context is, the lower the participation of women in the labour market. Besides, according to the same study, the fact that a woman has a partner (married or cohabiting) significantly reduces her participation in the labour market.

Trend 2: The share of women employed in large-scale mining is gradually increasing.

Over the past 8 years, most countries in the baseline study experienced, on average, a slow upward trend in female employment in large-scale mining, as highlighted in Figure 6. At first glance, the share of women's participation and the pace of increase remains low.

It is worth noting that mining employment is positively correlated to the performance of the mining sector, the overall economic situation of mineral-rich countries, and the global economic outlook. For instance, it was noted that mining employment—in particular for women's employment which, as will be discussed later, is especially affected by economic downturns—dropped in almost all countries between 2012 and 2015, a period which was marked by the slowdown of global economic growth. This was a result of the 2008 financial crisis, which further led to rising debt globally, culminating in a Eurozone crisis in 2012 and the slowdown of the Chinese economy. These had knock-on effects on the demand for minerals, on commodity prices, and hence on mining jobs, as mining investments slowed, and projects were put on hold. From 2015 onward, as economic growth picked up again, employment rebounded, and the rate of women's participation in mining increased concurrently.

FIGURE 6. Trends of women employed in large-scale mining from selected countries (2012–2019)
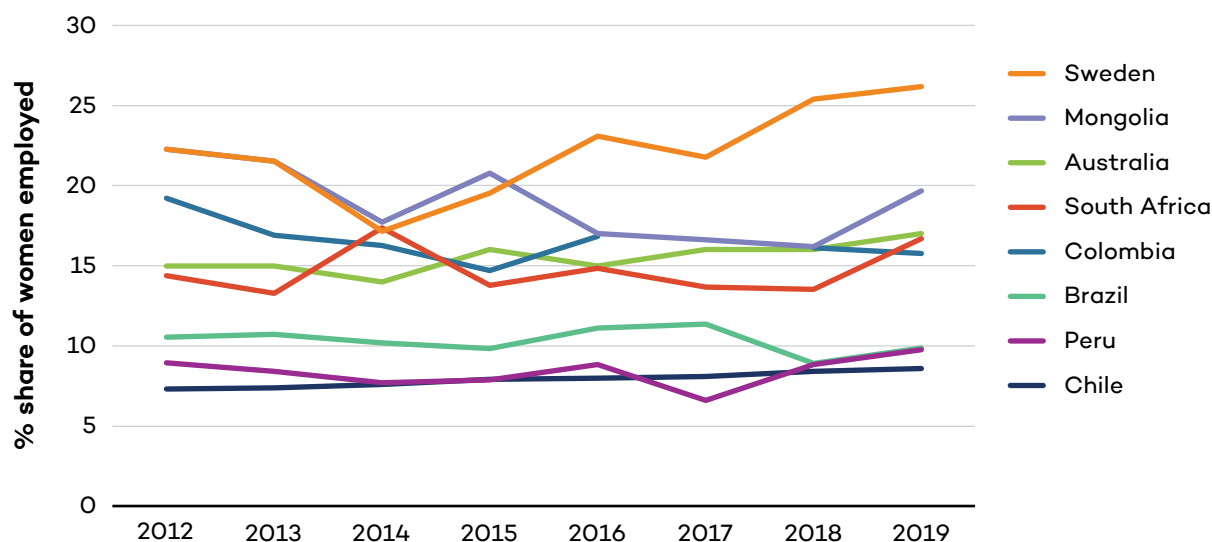
Source: Authors' calculations based on ILO data from 2012–2019, except Australia, which used data from the country report.[6]

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6 Not all countries have data for the entire period.

In addition to the structural factors in the global economy, positive changes in specific countries are worth highlighting. The increase in female participation in mining in Sweden since the early 2000s was largely attributed to new technologies adopted by the industry. More sophisticated mines contributed to changing the nature of work and the work environment in mining workplaces, making it possible for both men and women to perform certain tasks traditionally associated with physical strength (IGF, 2022i). However, findings from the analysis of workplaces show that, despite these positive changes, cultural aspects still emphasize that the "real" mining work requires "male" skills, therefore perpetuating the heavy presence of men in the mining work force, standing at 77% in 2020.

In Brazil, from 2009 to 2019, the number of women participating in the mining workforce increased from 3,442 to 7,816 (127%) compared to men, whose participation increased by 110%. Mining was not an exceptional sector in this regard, as a similar trend was observed across other sectors. The factors that favoured the overall growth in female participation in the labour market in Brazil are attributed to an increase in women's education, the reduction in the fertility rate, and advances in the possibility of reconciling family and work, among others. One can argue that the same factors may have influenced the growth of women's participation in the mining sector. Increases in women's participation in the sector, in particular after 2015, are also evident in the other countries, although Peru, Chile, and Argentina still rank as having the lowest participation of women from the baseline countries.

By contrast, in South Africa (IGF, 2023i), overall employment in the mining industry declined, in part due to the decline in the gold sector. From 2012 to 2019, the sector lost 23,285 formal jobs. However, gender parity still improved by 4%.

HIGHLIGHT #2: INDUSTRY-LED INITIATIVES TO SUPPORT WOMEN'S INCLUSION ARE PICKING UP THE PACE.

There seem to be some positive changes on the corporate side driven by global initiatives. Many mining companies in Brazil, such as Vale S.A., Nexa Resources, Anglo American and Mineração Rio do Norte, are responding to global voluntary standards or have strong environmental, social, and governance (ESG) commitments to end discrimination against women. In South Africa, the Bloomberg Gender-Equality Index tracks the performance of public companies committed to disclosing their efforts to support gender equality. These companies include Anglo-Gold Ashanti, Gold Fields, and Impala Platinum Holdings. In Australia, BHP has launched an initiative to improve diversity and gender balance. Female representation in its workforce has increased from 17% in 2016 to more than 30% in 2022. Women's representation in leadership also grew to 38%. BHP also has a "New to Industry" program that runs training programs in the Bowen Basin for Indigenous Australians in mining. In 2020, 75% of the 80 trainees were women. These initiatives encourage a more inclusive environment within some companies (IGF, 2022a, 2022b).

Trend 3: Women in the mining sector are more vulnerable to losing their jobs during economic downturns compared to men.

Although on average, the share of women's participation in the large-scale mining workforce is gradually increasing, a few country reports pointed to the vulnerabilities in sustaining their jobs during economic downturns, downfalls in sectoral performance, and global crises. In fact,

while their employment rate tends to increase more sharply than men during boom periods, women are more likely to be laid off during crises.

In Mongolia (IGF, 2022f) women's employment rate in mining increased significantly during boom years. In 2019, a boom period for the sector, 2,465 mining jobs were created for women, while, surprisingly, 2,752 jobs were cut for men. However, in the years when the total number of jobs in mining declined, women's employment rate declined by a higher rate compared to men. For instance, in 2020, during the pandemic, men's employment rate in mining fell by 7.4%, while women lost 34% of their mining jobs. This shows that while the growth of the mining sector in Mongolia seems to be more supportive of women's employment than that of men, women are more likely to be laid off than men when the sector's operations slow down. Women's jobs in mining are therefore more volatile, which is a challenge for their retention and for their employment security.

In Ghana (IGF, 2022e), a similar trend was seen. When the quarrying sector is excluded, women made up 13.5% of the workforce in large-scale mining and their contractors in 2017, which fell to 8% in 2019, following the sector's downturn. The report attributed this drop to the type of occupations women hold in the sector, such as administrative roles and community and personal services, which could be more likely to be impacted by budget restrictions and, hence, subject to decline with a downturn.

HIGHLIGHT #3: HOW WOMEN WORKING IN MINING IN CANADA ADAPTED TO COVID-19.

During the pandemic, the female labour force in Canada was overall more negatively impacted than the male labour force. However, women in the mining workforce were found to be more resilient to the disruptions brought about by the COVID-19 pandemic. Since women in mining worked in professions that could be adapted for remote working, such as professional, leadership, or support staff roles, they were relatively less impacted than women in other sectors by disruptions caused by lockdown policies and economic decline (Mining Industry Human Resource Council, 2021).

Assumption 3: Working conditions[7] in the mining sector are not conducive to women's employment.

Facilities, especially at mine sites, are not conducive to women's employment. Facilities and equipment are often not adapted to the needs of women and the fly-in fly-out (FIFO) model for mines located in remote areas, which is a challenge for women trying to balance responsibilities at home and at work. Expectations associated with women and childcare provide an added obstacle to their employment, especially in remote locations. When combined with the low level of part-time work compared to other sectors, the industry's culture of overwork, long hours, and intensity (which further burdens women due to their care duties at home) and the remote nature of the work, the sector becomes hostile to the employment of women. Reports of discrimination (in terms of employment opportunities) and of violence, harassment, and sexist attitudes associated with the sector further impede women's participation in mining.

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7 Working conditions related to wages and number of hours worked are covered below following Assumptions.

THE INTERNATIONAL LABOUR ORGANIZATION AND UNDERSTANDING WORKING CONDITIONS

Since its founding in 1919, the government, employer, and worker constituents of the ILO have worked to set labour standards, develop policies, and devise programs promoting decent work for all women and men. With its mission to promote social justice and internationally recognized human and labour rights, the ILO underlines the critical importance of establishing humane conditions of work as a means to achieve its vision of universal and lasting peace.

The core elements of any employment relationship and of workers' protection (which also affect economic performance), include wages, working time, work organization and conditions of work, arrangements to balance working life and the demands of family and life outside work, non-discrimination, and protection from harassment and violence at work. Working conditions cover a broad range of topics and issues, from working time (hours of work, rest periods, and work schedules) to remuneration, as well as the physical conditions and mental demands that exist in the workplace.

To that end, the ILO promotes cooperation between key labour market institutions to foster their potential combined positive effect on worker protection, labour market performance, and equality. This includes, among other things, collective bargaining, employment security, wages, working time, and the balancing of work with family obligations. These issues are subject to numerous ILO conventions and recommendations that should be ratified and effectively applied in order to sustainably improve working conditions.

There are over 400 international labour standards and instruments that establish an international legal framework on labour issues covering all sectors of the economy, including large-scale and artisanal and small-scale mining.

To the extent possible, this paper has tried to present information on the different topics and issues that together can ensure decent working conditions.

Trend 1: Basic facilities and equipment are still designed for male needs.

The lack of proper facilities, especially in operational areas, has been highlighted in several country reports. A WiM Brazil survey (WiM Brazil; EY: 2021) conducted among 16 companies found that 38% of the respondents disclosed that the workplace had not adopted proper facilities for women, while only 50% of the companies had equipped the workplace according to the needs of women. The same survey found that 67% of respondents disclosed having personal protective equipment (PPE) suited for both women and men, an issue closely linked to work safety and often regulated by rules and laws. The Brazil baseline country report further discloses that women's demands regarding working conditions also include appropriate uniforms and PPE for pregnant women, as well as safe and dedicated basic facilities such as bathrooms and locker rooms for women.

The South Africa baseline country report conducted a qualitative study completed by 452 women working in large-scale mining. The survey responses indicated that mining companies have disparate strategies and corporate measures to ensure that women have appropriate PPE, safe and separate sanitation facilities, and gender-appropriate health services.

The absence of basic facilities—like separate and appropriate bathrooms, changing facilities and accommodations, and PPE adapted to the physiological and safety needs of women— very likely affects women's willingness to work in the mining industry, especially on mine sites and in operational areas. The Queensland Resources Council in Australia specifically offers audits of on-site facilities for women, including accommodation, changing facilities, toilets in operational areas, and breastfeeding facilities to try and redress this specific problem with facilities and equipment.

Trend 2: Women in mining are mostly employed in urban areas.

Large-scale mining operations generally occur in remote areas. When local communities exist, mining companies tend to recruit workers from the local force to the extent that the required skills are available. However, in some cases, mining operations involve FIFO staff, which means that workers are temporarily transported to mine sites by air to work for a limited period, often on a rotational basis, before being transported back to another location.

Despite extraction activities being concentrated in remote locations, many mining jobs exist in urban areas, in headquarters or offices, where a larger share of women tend to be concentrated. The ILO data shows that the percentage of women working in urban areas tends to be higher, with the notable exception of Ghana, where women were employed exclusively in rural areas (see Highlight #4 below).

FIGURE 7. Share of women in urban versus rural areas
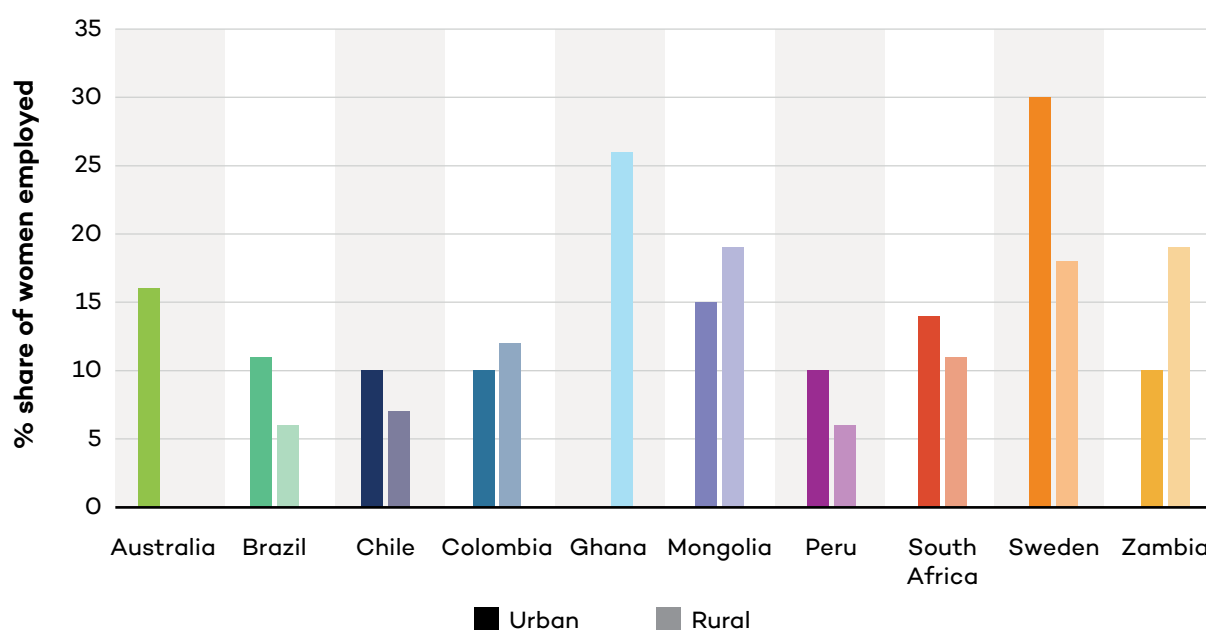
Source: Authors' calculations, ILO statistics, 2018, except Australia, 2016; Chile and Ghana, 2017.

Country reports also confirm this trend. In Australia, women constitute 20% of the mining workforce in major urban settings, such as Melbourne and Perth, whereas in rural settings, this ratio falls to 12%–14 %. In the country as a whole, 85% of women are employed in urban areas. The report points out that the mining environment in remote areas and FIFO work arrangements may expose women to an increased risk of harassment.

FIFO conditions can be a challenge for women employees, in particular considering the gendered division of labour that puts the burden of family responsibilities and care work expectations and demands mostly on women and girls. Also, in some cases, rural employment involves local women who already reside in mining communities.

In Sweden (IGF, 2022i), the capital Stockholm has the highest share of women, likely due to the location of offices and headquarters. The relatively high share of women employed in the mining and quarrying industry in Norrbotten (27% women) and Västerbotten (21% women) potentially relates to the fact that the large mining workplaces are located here. Large workplaces tend to require a larger share of administrative personnel, and as administrative work tends to be associated with women, this may be reflected in the share of women.

HIGHLIGHT #4: THERE ARE A FEW NOTABLE EXCEPTIONS TO THE CONCENTRATION OF WOMEN IN URBAN SETTINGS.

The opposite trend is observed in Brazil (IGF, 2022b). Between 2009 and 2019, the majority of the Brazilian mining workforce (77% of men and 63% of women) worked in rural areas, due to the fact that most mining companies maintain their operations and main facilities in remote locations far from urban centres. In some cases, mine sites may only be accessible by air or by river, making commuting and FIFO difficult and time consuming. Companies therefore invest in programs to recruit young people from local communities, including by providing facilities to accommodate employees' families, whenever necessary, so that people accept working in remote locations and by providing services such as schools, health centres, and housing.

In Ghana, while the average employment of women in mining was 18% in 2017, in rural areas this percentage rose to 26%. This was explained in the report by the overall higher employment in rural settings compared to urban settings. The report explains that the greater availability of jobs in rural settings might contribute to women's willingness to work in remote areas despite the likely challenges of abuse and discrimination that they commonly face in those areas.

Trend 3: While parental leave provisions often go beyond minimum national requirements, sector-specific challenges impede their full implementation.

Initial research undertaken by the IGF as part of this project looked into the maternity leave policies[8] in the 12 study countries. The preliminary findings revealed that they all provide legislative frameworks for maternity, and to some extent paternity, parental, and breastfeeding leave, in addition to other safety regulations for pregnant and lactating women.

A review of publicly available mining company parental leave policies demonstrated that in almost all cases, companies do provide parental leave that surpasses minimum national requirements and minimum ILO requirements, but few have policies in place that create effective equality of opportunity and treatment for men and women workers that have care or support responsibilities at home that restrict their possibilities of preparing for, entering,

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8 This document will be published shortly.

participating in, or advancing in their profession.[9] Companies that adopt a global minimum standard, such as Rio Tinto and BHP, by far surpass minimum national requirements (see Appendix C).

However, the data demonstrate that despite appropriate—and at times generous—on-paper maternity leave and flexible work arrangements for the safety of pregnant individuals, there seems to be a problem with their implementation. Countries have complex legal provisions for the safety of women, and most stipulate that pregnant and breastfeeding employees should not be required to be exposed to certain hazards. While mining companies are obliged by law to offer suitable alternative employment, it was reported through qualitative interviews in the South Africa and Mongolia baseline reports that some women did not receive appropriate alternatives, or that some women saw their contracts terminated due to pregnancy. This can lead to women refusing to disclose their pregnancy status or simply deciding to leave the sector when expecting.

The Australia baseline report also highlighted that the lack of childcare services following parental leave, especially in remote locations, hinders women's return to work in mining. This is likely disproportionally affecting women's employment since they are often expected to shoulder childcare responsibilities. A 2019 women's report card in the Western Australian Department of Communities revealed that 57% of women identified poor access to childcare in remote locations as a barrier to their participation in the sector (IGF, 2022a). In the Mongolia baseline report, interviewees listed expectations surrounding the care of children and work–life balance as challenges for women's employment in mining.

The Peru baseline report (IGF, 2022g) mentions the Law No. 30367, which protects the working mother against arbitrary dismissal and extends her rest period. This law protects women from being fired for reasons of pregnancy, childbirth and its consequences, and lactation. Likewise, it extends the rest for mothers up to 49 days before and after giving birth. Some mining companies in Peru complement the maternity leave (usually 3 months) with a period of paid leave for a period of up to a maximum of 6 months. Even so, the Peruvian report recognizes that in order to eventually increase women's participation in mining, companies must have clear plans for women before, during, and after pregnancy. Those should include clear policies on the type of work women can undertake while pregnant, commitments to suitable light-duty alternatives, and childcare facilities near work centres to facilitate women's return to work.

Trend 4: Sexist attitudes, violence, harassment, and gender-based discrimination are prevalent in mining.

Sexist attitudes and harassment were mentioned in several reports as affecting women's likeliness of working in large-scale mining. This has been reported as taking place as early as during their education and training periods, in particular in STEM-related fields, and continued during their careers in mining. For instance, the Australia baseline report revealed that women face stereotypes and biases that might deter them from studying STEM subjects, and once employed, might face gender discrimination and sexual harassment at the workplace (IGF 2022a).

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9 Maternity Protection Convention, 2000 (No. 183); Maternity Protection Recommendation, 2000 (No. 191); Workers with Family Responsibilities Convention, 1981 (No. 156); Workers with Family Responsibilities Recommendation, 1981 (No. 165)

Research highlighted in the Canadian baseline study showed that women who find themselves being the "only" woman in a department are more likely to face biases and discrimination than women who work with other women (LeanIn & McKinsey & Company, 2021v). Rio Tinto's recent external review of workplace culture (Rio Tinto & Elizabeth Broderick & Co., 2022) showed that the prevalence of sexual harassment is much higher for women (27%) than for men (5%) in their Canadian operations. The report also indicates that these incidents are less likely to be denounced or resolved (Rio Tinto & Elizabeth Broderick & Co, 2022).

In Australia, the Chamber of Minerals and Energy (IGF, 2022a) found that women working in remote mining towns are more exposed to risks of sexual harassment and discrimination. An analysis of Rio Tinto's external review of workplace culture also found that harassment, assault, and bullying are rife among its workforce in Western Australia (IGF, 2022a). This pattern of violence and harassment of women in mining was corroborated by the South Africa report where surveys conducted of women working in mining found incidents of sexual harassment and gender-based violence were still occurring, including in underground mines.

Underreporting of violence, harassment, and discrimination is also likely to be prevalent across mining. In Canada, Rio Tinto & Elizabeth Broderick & Co. (2022) found that incidents often went underreported, frequently unresolved, and often ended up impacting women more than men. Another Canadian study corroborated those findings, reporting that 78% of discrimination and harassment incidents went unreported and only 17% resulted in the aggressor's behaviour stopping (IGF, 2022c). Underreporting can happen for a variety of reasons, including fear of retaliation. Additionally, since workplace discrimination and harassment are often reported and managed separately from workplace health and safety incidents, data on discrimination and harassment remains largely invisible.

Assumption 4: Women are underrepresented in certain mining occupations and overrepresented in others.

There is a general perception that women are underrepresented in certain occupations and overrepresented in others. A closer analysis of occupations taken up by women in large-scale mining underscores some nuances in the types of jobs women perform and the positions they hold in the industry. It provides further insights to understand whether their gradual integration in the sector is still governed by gendered patterns of employment.

Data gathered from the ILO based on ISCO's occupations classification provide an overview of the types of jobs that women hold in large-scale mining. Significant differences are noticeable, as shown in Figure 8,[10] which demonstrates the variety of professions and fluctuations across different countries. This variability can be, to some extent, explained by differing skill sets available in countries. The following trends highlight the nuances observed in different types of occupations as gathered in the country baseline reports.

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10 One of the occupation groups (agriculture, forestry, and fisheries) was left out of the figure due to the increment size.

FIGURE 8. Percentage of female employees by occupation group (all countries)
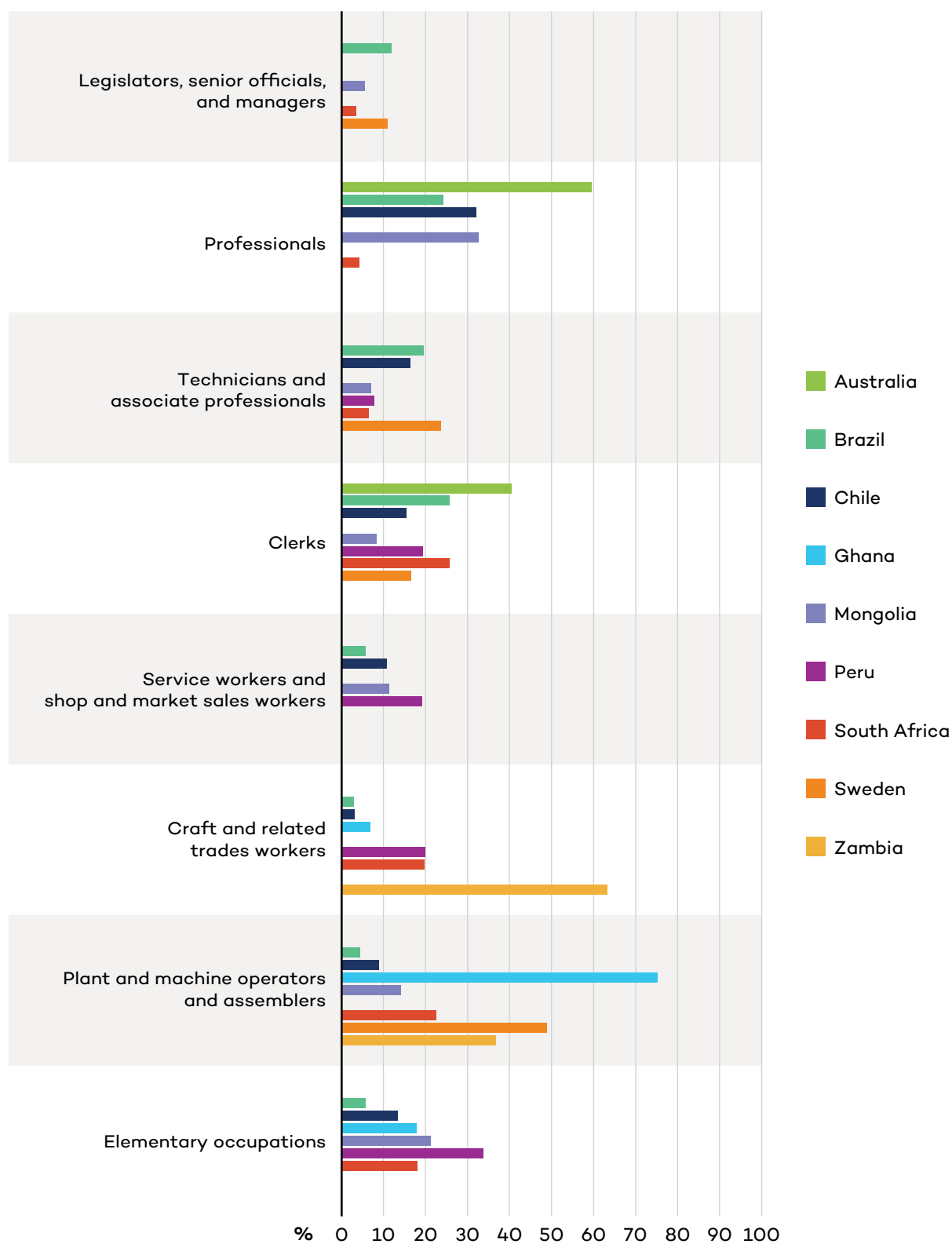
Source: Authors' calculations, based on ILO ISCO database, (2018), except Australia, ISCO database, 2016; Chile and Ghana, ILO ISCO database, 2017. Note: The occupation group is based on ISCO-08, with the exception of South Africa, which uses ISCO-88.

HIGHLIGHT #5: HOW ARE OCCUPATIONS CLASSIFIED?

According to the ILO, the term "occupation" refers to a "set of jobs whose main tasks and duties are characterized by a high degree of similarity." The ILO uses the International Classification of Occupation (ISCO), a framework covering 10 major groups of occupations that are comparable across countries. These are, in turn, divided into sub-groups to reflect specialization.

The 10 major groups are (1) managers; (2) professionals; (3) technicians and associate professionals; (4) clerical support workers; (5) service and sales workers; (6) skilled agricultural, forestry, and fishery workers; (7) craft and related trades workers; (8) plant and machine operators, and assemblers; (9) elementary occupations and (10) armed forces occupations.

The latest version of ISCO is ISCO-08, published in 2008. It is currently being revised, with an expected release date of 2028.

Trend 1: Women are generally concentrated in clerical and support positions.

Most country reports confirmed that women employed in the large-scale mining sector tend to be more concentrated in administrative, clerical, and support services. These include tasks such as keyboard clerks, customer services, general office clerks, and secretaries. As can be seen in Figure 9, several positions under this occupational category can vary across countries. In both Brazil and South Africa, within the "clerical workers" occupational category, women mainly occupy jobs as office clerks, and to some extent accounting and bookkeeping. In the future, those occupations could be at risk of changing because of automation, sophisticated machines, and artificial intelligence.

Women in the Australian mining workforce between from 2010–2020 were concentrated in occupations such as clerical support (65%), sales (45%), and community and personal services (34%). However, looking at the evolution of employment by occupation and sex from (2010/11 to 2020/21), findings indicate a gradual trend in decreasing clerical support positions typically held by women.

Similar trends are observed in Sweden (IGF, 2022i) where women accounted for the highest share of jobs in clerical support, where they held 73% of all jobs in this category followed by service and sales (42% of total jobs) in 2019.

FIGURE 9A. Percentage of female clerical workers in mining, Brazil, 2012–2020
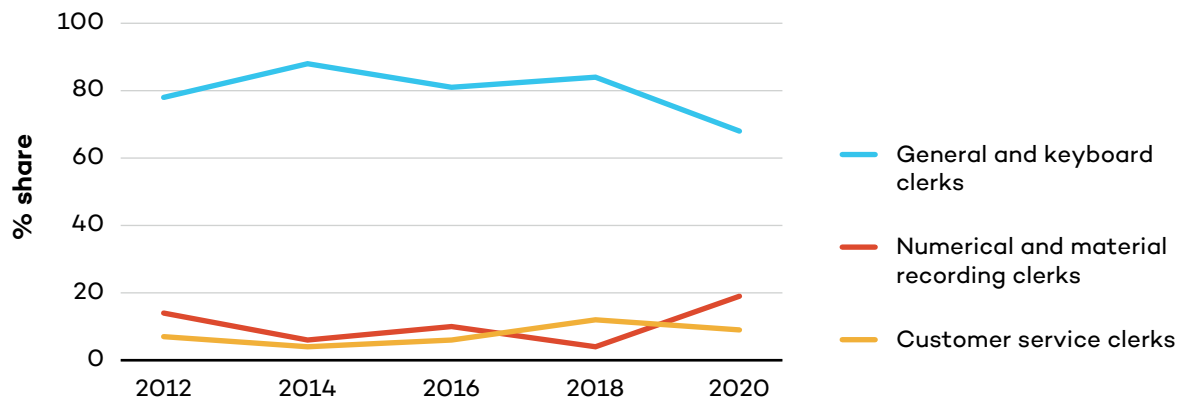
FIGURE 9B. Percentage of female office clerks, South Africa, 2012–2020
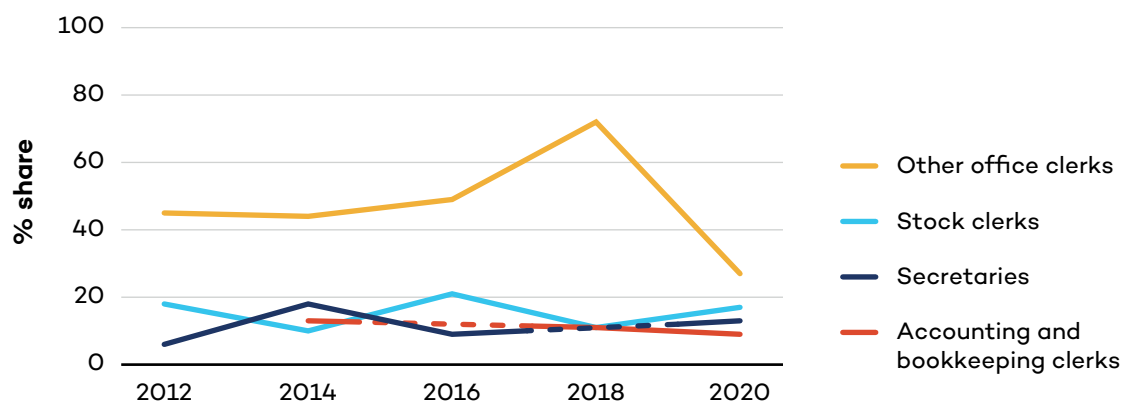
Source: Authors' calculations, based on ILO ISCO database, 2012, 2018, 2020.
Note: Dotted line indicates no data for that year.

HIGHLIGHT #6: WOMEN IN BRAZIL ARE MORE REPRESENTED IN OCCUPATIONS OTHER THAN CLERICAL SUPPORT SERVICES.

Brazil, however, shows a different trend: Interestingly, the top three job categories employing women in the mining sector between 2009 and 2019 were mid-level technicians, accounting for 27% of all female mining employees; professionals (23%); and production of industrial goods and services (19%). Clerical support services ranked fourth, with only 15% of the female mining workforce. This may be another case of a shift toward more gender parity.

Trend 2: Women are underrepresented as technicians and associated professionals, craft and related trade workers, and plant and machine operators.

The data from both the ILO and the baseline country reports confirmed that women tend to be largely absent in several occupations, including technicians and associated professionals, crafts and related trade workers, and plant and machine operators.

HIGHLIGHT #7: A BRIEF OVERVIEW OF ILO OCCUPATIONS AND SKILLS CLASSIFICATIONS

The ILO associates different occupations with different skill levels—or functions, tasks, and duties required of an occupation—ranging from 1 to 4. Skill level 1 typically involves "the performance of simple and routine physical or manual tasks."

Skill level 2 typically involves "the performance of tasks such as operating machinery and electronic equipment, driving vehicles, maintenance and repair." In mining, craft and trade workers and plant and machine operators would fall under skill level 2.

Skill level 3 is defined as "the performance of complex technical and practical tasks that require [...] factual, technical, and procedural knowledge." This includes technicians and associate professionals.

Skill level 4 is defined as "complex problem-solving, decision-making, and creativity based on an extensive body of theoretical and factual knowledge in a [...] field" (ILO, 2012). This skill level encompasses Professionals.

First, looking at technicians' occupations data, comparative data from the ILO for Brazil, Mongolia, and South Africa show that over the years, the number of female technicians remained rather low and, with the exception of Brazil, below the average of overall female employment in mining.

FIGURE 10. Percentage of female technicians in mining occupations, 2012–2020
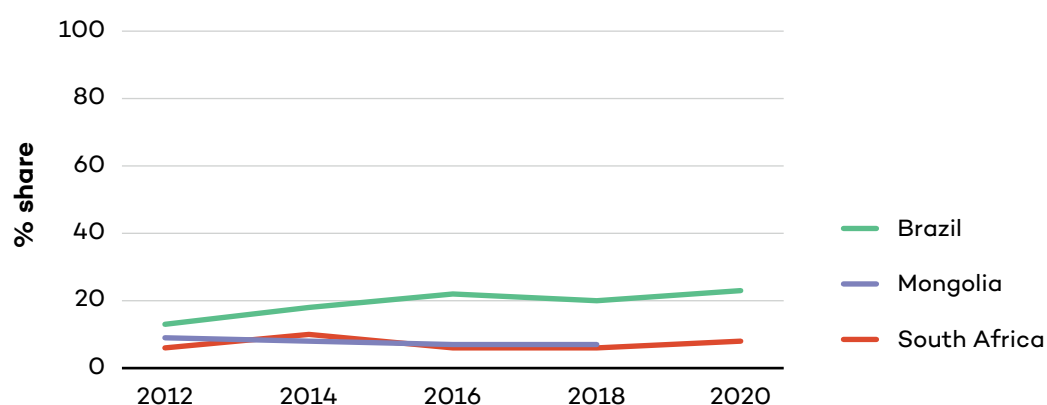
Source: Authors' calculations, based on ILO ISCO database, 2012, 2018, 2020.

Further disaggregated technicians' occupation data from Brazil provide some insights about the different types of technical jobs performed by women and highlight the trends in those occupations in the last 6 years. As can be observed in Figure 11, women working as technicians in Brazil are mostly employed as science and engineering associates. Although health associate professionals and business and administration associate professionals have remained fairly constant in the past 4 years, women in science and engineering positions experienced a slight decrease between 2012 and 2018.

FIGURE 11. Percentage share of technicians (associate professionals), Brazil, 2012–2020
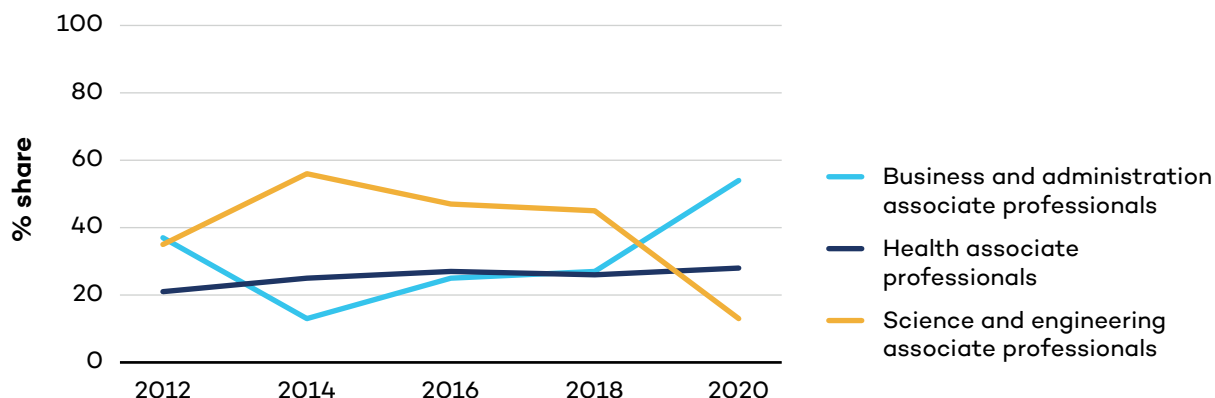
Source: Authors' calculations, based on ILO ISCO database, 2012, 2018, 2020.

FIGURE 12A. Female drivers and mobile plant operators % composition, South Africa
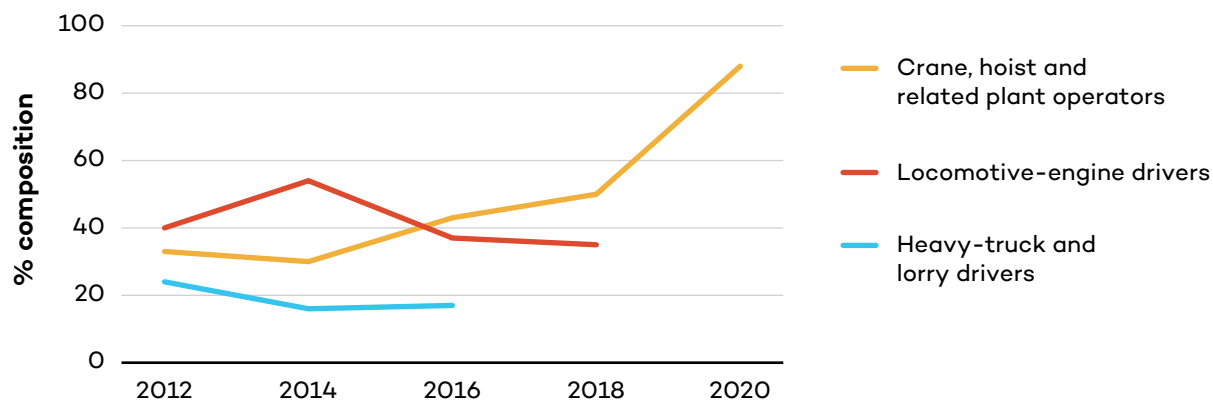
FIGURE 12B. Female plant & machine operators and assemblers, % composition, South Africa
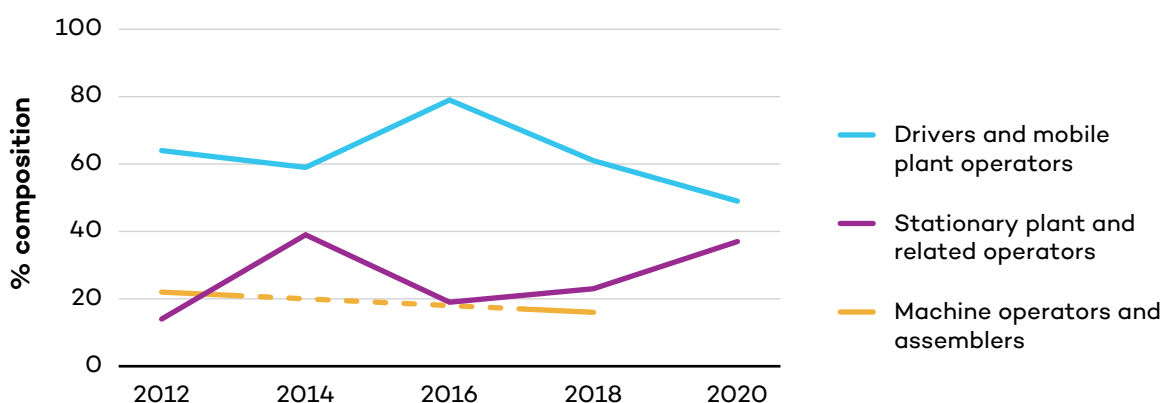
Source: Authors' calculations, based on ILO ISCO database, 2012, 2018, 2020.
Note: Dotted line indicates no data for that year.

In Mongolia, the country case study revealed that plant and machine operators and assemblers, which account for 47% of all large-scale mining workers, represented a share of 95.2% of men and only 4.8% of women. The report explained that it could be difficult

for women to work in the sector due to harsh working conditions and predominant gender stereotypes (IGF, 2022f). This finding is further confirmed by ILO data, although with the added caveat that while women's participation in stationary plant and machine operator roles is decreasing, the majority of women in technical jobs are found as drivers and mobile plant operators.

The South African baseline study demonstrates that men dominate most technicians' occupations. Regarding plant and machine operators, ILO data provide some granular insights into this occupation category. As Figures 12.a and 12.b highlight, between 2012 and 2018, women mainly perform tasks as drivers and mobile plant operators, and in particular operate crane, hoist, and related operations, and to a lesser extent, locomotive engines and heavy truck and lorry drivers.

Other jobs performed by women in South Africa include craft and related trade works. Women in those occupations are mainly employed as extraction and building trade workers and as miners and quarry workers, and less often in metal, machinery, and related trades work or as electricians, which require some specific vocational skills which they may lack (see Assumption 5 Trend 2).

In Sweden, a high-income country, the country baseline study shows that men predominate among craft and trade workers (92%) and plant and machine operators and assemblers (83%). However, a shift in women employed as machine operators, going from 13% in 2014 to 17% in 2019, indicates that more women are picking up these jobs, even if the number is still well below national average representation of women in mining (IGF, 2022i).

FIGURE 13. Female craft & related trades workers, % composition, South Africa
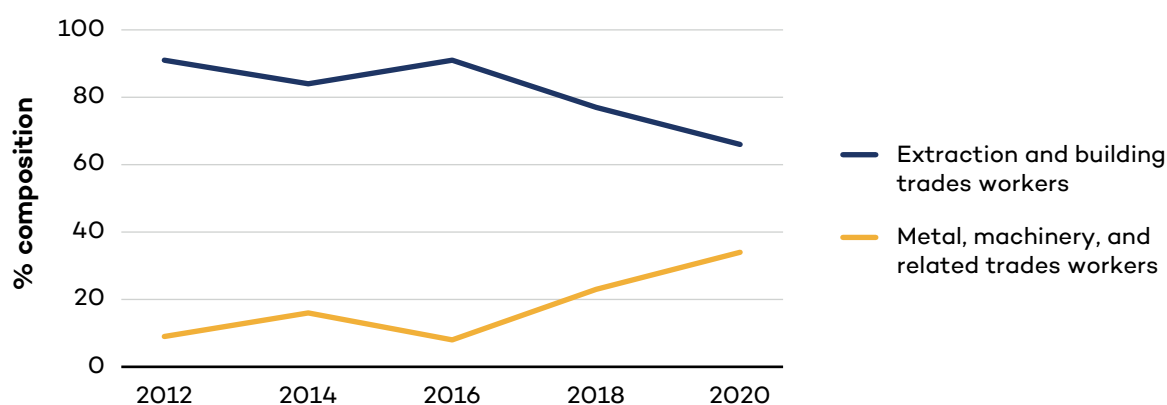
Source: Authors' calculations, based on ILO ISCO database, 2012, 2018, 2020.

Unsurprisingly, in Australia between 2010 and 2020, occupations such as technicians and trades, and machinery operators and drivers were also male dominated. However, the baseline report observed a slight increase in women's share of jobs such as machinery operators and drivers and professionals, occupations that are not traditionally thought of as occupied by women. This was paralleled by a decreasing trend in male employment in the same two occupations. Although very gradual, these changes were consistently observed over a 10-year period, signalling a positive shift in the participation of women.

However, this trend deserves a word of caution: although this shift is positive for women in large-scale mining, it may be associated with the adoption of new technologies, such as

automation, rather than progress in conditions of access to women. A recent report found that occupations such as machinery operators and drivers may offer fewer prospects in the future (IGF, 2022a). This trend in favour of women and the decline in male employment in those jobs may indicate that men could be shifting their interests toward jobs that are in higher demand due to new technologies, which may, in turn, open opportunities for women in less attractive jobs that might be automated. However, these opportunities may be short-lived and may potentially distract women from more sustainable jobs.

HIGHLIGHT #8: PERU: WOMEN ARE UNDERREPRESENTED IN ALL OCCUPATIONS.

Photo: Rain...

In Peru (IGF, 2022g), women's underrepresentation is noteworthy, occurring not only in operational and technical occupations but also in those functions that have historically been dominated by women. In clerical support occupations, women accounted for only 1% of total mining jobs compared to 5% for men. In the case of plant and machine operators and assemblers, the discrepancy is even larger, where women are totally absent, and men represent 18% of the total mining workforce.

The country baseline report (IGF, 2022g) attributes this low proportion of women employed in operational and technical occupations to their skill levels, and in particular to the fact that only a third of all female graduates from tertiary education have STEM qualifications.

Trend 3: Women are less represented in the "professionals" occupational category except for business and administration.

ILO data on Brazil occupations provide an interesting insight regarding professionals, an occupation category that requires specialized sets of skills, such as STEM, and generally related to complex problem solving, as underscored in Highlight #7. When looking at specializations, it is found that the majority of women working in mining are in business and administration. In science and engineering, an increase in the early 2010s suddenly dropped in 2018. It is worth noting that the share of women professionals in the information communications and technology (ICT) professions, an area that is key for future digital jobs, is extremely low and constantly declined between 2012 and 2018.

FIGURE 14. Professionals in mining, percent composition, Brazil, 2012–2020
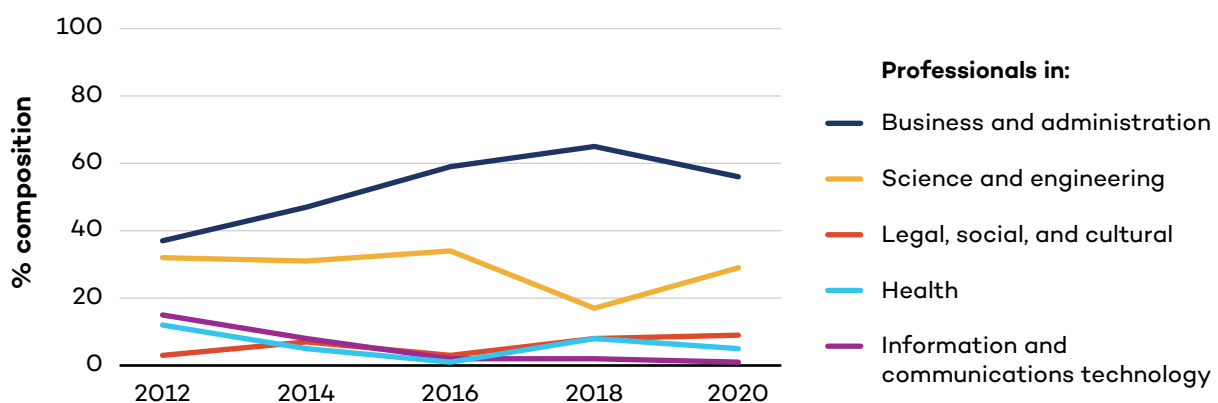
Source: Authors' calculations, based on ILO ISCO database, 2012, 2018, 2020.

Figure 15 provides some granular insights into the field of specialization of female professionals in Mongolia. It is not surprising to observe that women dominate in business and administration professional occupations and are less present in STEM fields. Unlike in Brazil, their participation in these technical occupations had improved between 2012 and 2018, before the overall decline in women's participation in 2020.

FIGURE 15. Professionals in mining, percent composition, Mongolia, 2012–2020
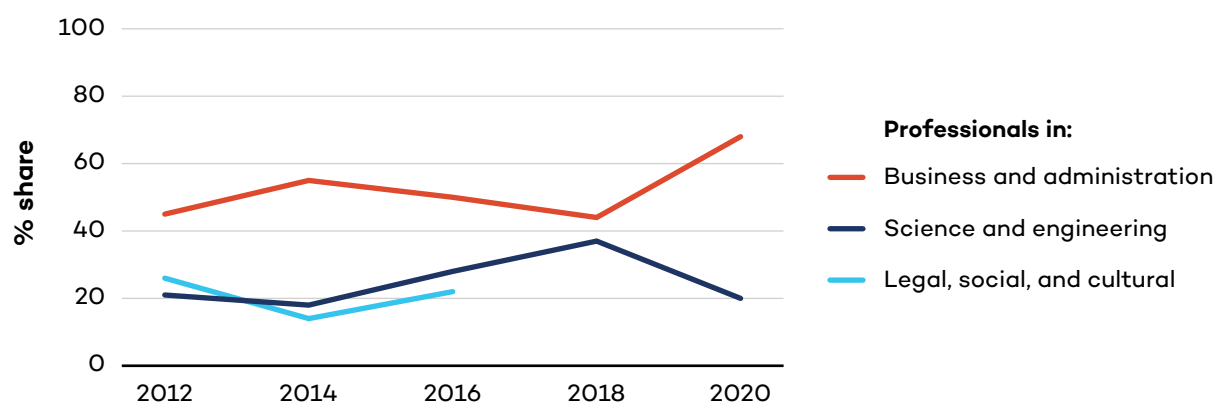
Source: Authors' calculations, based on ILO ISCO database, 2012, 2018, 2020.

In South Africa, the baseline study found that in 2019–2020, women made up 35% of professionals in mining, which is well above the national average of women employed in the sector. ILO data on occupations highlighted one interesting trend for physical, mathematical and engineering science professionals. Figure 16 shows that the share of women within the group of professionals is fairly well distributed, with a progression noted for physical, mathematical and engineering occupations.

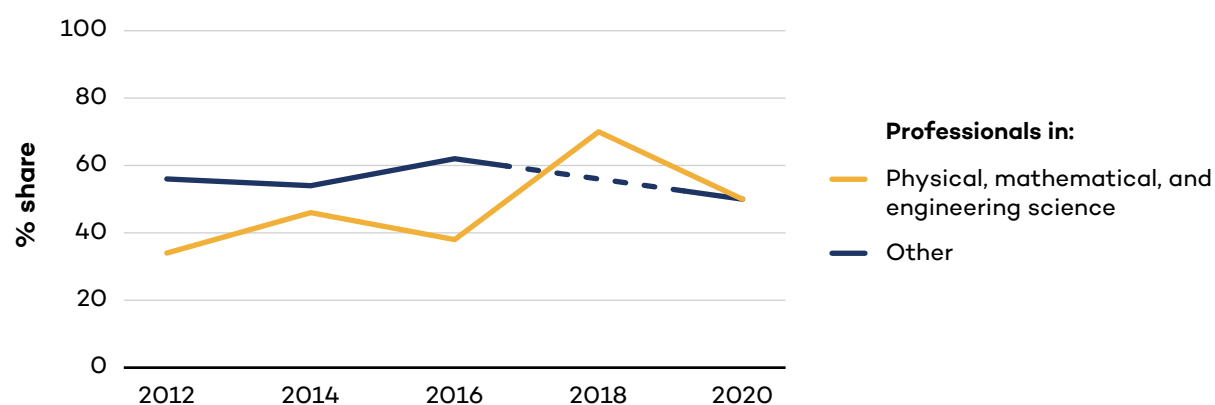**FIGURE 16.** Professionals in mining, percent composition, South Africa, 2012–2020

Source: Authors' calculations, based on ILO ISCO database, 2012, 2018, 2020.
Note: Dotted line indicates data was not available.

HIGHLIGHT #9: WOMEN'S SKILLS ARE UNDERUTILIZED IN THE AUSTRALIAN MINING SECTOR.

The Australian baseline study (IGF, 2022a) pointed out an important point: while the lack of progress in the overall female share of employment in the mining sector is a concern, an even greater one is the underutilization of women. Underutilization happens when a qualified person is employed in a position that does not use their full potential or provide full-time work due to reasons such as overstaffing, being overqualified, and technological changes.

In the Australian study, there is a significantly higher underemployment rate of the female workforce as a proportion of total employed than that of men for almost the entire 11-year period. Such high underemployment in the sector could drive female workers out of jobs.

Trend 4: Women are underrepresented in professional, managerial, and leadership positions.

Women are less represented in managerial positions, which are also associated with seniority as well as decision-making and leadership roles. In Australia (IGF, 2022a), a small average of 16% of women occupied managerial positions. The Australia report points out that women working in large-scale mining commonly experience men's exclusionary behavior, which results in women's exclusion from information and decision making, men recruiting in their own image, engaging in practices that ostracise and undermine women and maintaining ways of working that are comfortable for men and which do not challenge the status quo. (MCA, 2007, p. 50, cited in IGF, 2022a)

A similar trend was observed in Sweden, where men continue to predominate at the highest managerial levels of the industry. Despite presenting the highest proportion of female workers in mining, Swedish women's proportional representation is decreasing in managerial positions: in 2014, men constituted 73% of all managers while in 2019 their share in managerial positions increased to 79%. Brazil saw an increase in the number of female managers, mainly from 2018 onward. However, the proportion of women in leadership roles remains low compared to men, averaging 27% between 2009 and 2019.

In Tables 3 and 4, a closer look at the ILO breakdown for managerial positions women held in Brazil between 2012 and 2020 reveals that women mostly held administrative leadership roles, as opposed to specialized leadership roles, confirming the trend observed earlier about the very low presence of women in professional occupations.

TABLE 3. % composition of women managers, Brazil 2012–2020

	2012	2014	2016	2018	2020
Administrative and commercial managers	74	87	78	60	98
Production & specialized services managers	26	n/a	12	40	n/a

TABLE 4. Further breakdown of administrative and commercial managers (% share), Brazil 2012–2020

	2012	2014	2016	2018	2020
Finance managers	n/a	28	10	35	56
Human resource managers	46	15	n/a	n/a	n/a
Business services and administration Managers not elsewhere classified	34	45	63	41	18

Source: Authors' calculations, based on ILO database, 2016–2020.

While the project sought to uncover data that reveals women's participation in different phases of the mining life cycle, this data was available for only a handful of countries. Nonetheless, the findings from the countries where the data existed showed that women are most absent in exploitation and most involved in the exploration (and, in some contexts, closure).

In Peru, greater participation is recorded in the exploration stage (10% on average) and less in the exploitation stage (6% on average). Women's participation in the economic activities related to mine closure was recorded at 5% at the beginning of 2020; however, this rose to 11% in 2021. Despite the absence of statistical data explaining this increase, interviews with experts from the sector suggest that this trend is due to the greater presence of female personnel in careers linked to environmental engineering, who work mostly in the evaluation of the mining impact activity in the communities after mining.

HIGHLIGHT #10: DEEP DIVE INTO INTERSECTIONALITY—HOW SOUTH AFRICA DISAGGREGATES BY ETHNICITY AND RACE[11]

Considering the proportion of South African employees in top management occupations by ethnicity and race, the baseline study reported that the country still grapples with racial inequality at the management level. The study reveals that men dominated the top management category overall (81%). There was a large discrepancy between Black African men (24%) and White men (68%) occupying top management positions. However, when looking at women, it is observed that White and Black African women accounted for 43% and 44% respectively. This slightly higher proportion of Black African women in top managerial positions can be attributed to specific empowerment programs targeting this group as specific local content targets specified in the Mining Charter, proving the impact of such initiatives and of government policies.

In South Africa, of the 452 women who responded to the survey, 14% were employed in exploration activities, 32% in discovery, evaluation, and development, 46% in processing, and 8% in closure. An equal percentage of women work in capital projects, process development, consulting, evaluation, and planning occupations. The data from South Africa also indicate that the breakdown of mining workforce by workplace is consistent for men working in open

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11 Statistics South Africa classifies the race as (Black) African, Coloured, Indian, and White.

cast mining, underground mining, and other activities, whereas most women work in sea mining environments and on surface (24.3%) than in open cast and underground mining.

Similarly, in Canada, women are most involved in exploration activities (29% of all exploration staff) and least involved in exploitation (14%) and manufacturing and fabrication (12%). While the reasons for this gendered division were not specifically sought under this project, possible explanations could include skills segregation and work culture-specific challenges as explained in the sections below.

Assumption 5: Barriers remain for women to obtain mining-specific skills and education.

In an attempt to explain the underrepresentation of women in core mining occupations, one could assume that women "lack" mining-specific skills and education. It is often believed that women simply do not have the correct skills or education to be recruited for mining-specific occupations, and therefore are more likely to fit into administrative or support roles. Assumptions like these are common and contribute to reproducing stereotypes that underlie the sexist bias present in work environments. Results from the 12 countries baseline studies provide a more nuanced analysis of the skills and educational profiles of men and women working in large-scale mining across the selected countries.

HIGHLIGHT #11: EDUCATION AND SKILLS: WHAT IS THE DIFFERENCE?

Although the terms are sometimes used interchangeably, "education level" is not synonymous with the skill levels one may have. Educational attainment is generally defined by the level of academic qualifications, such as high school certificates, bachelor, master, or doctorate degrees, obtained from recognized institutions, such as schools, colleges, vocational training, and tertiary institutions.

On the other hand, "skills" usually refer to one's capacity to perform a task or duties of a given job. According to the ILO (ISCO-08, 2012), two dimensions of skills are used to classify occupations: skill level and skill *specialization*. Skill level refers to "a function of the complexity and range of tasks and duties performed in an occupation." It is measured notably by the nature of work performed, the level of formal education received, and the amount of informal on-the-job training and/or experience acquired.

So-called "soft" skills are often described as being associated with one's traits and attitudes (leadership, networking, problem solving, communications), while "hard" skills are more often described as focusing on specific tasks and processes, such as the use of tools, equipment, or software, (information technology [IT], technical, etc.). Hard skills can be acquired through formal or vocational education, as well as on-the-job training programs and apprenticeships.

Trend 1: Overall, women in mining have higher educational attainment than men.

Data from the ILO show a cross-country comparison across nine countries, grouped by levels of education. Although different countries have different education systems, to enable comparison, ILO data was standardized according to four levels of education, as shown in Figure 17. In most countries, women in mining have high levels of education.

Figure 18 provides the perspective at a country level. Columbia, Peru, and Zambia have the highest levels of women employed in mining with only primary education or less. Brazil and Mongolia have the highest shares of women with advanced education in mining.

Different country baseline reports show that on average, women in large-scale mining have higher educational attainment compared to men. Of the 10 selected countries,[12] eight reported that a higher proportion of women joining the large-scale mining workforce have advanced levels of education compared to men. Zambia was one of the exceptions, where the share of women with advanced education was lower than men. While ILO data was unavailable for Ghana for recent years (IGF, 2022e), the country report showed a similar finding: data from 2017 indicated that no woman had advanced education, compared to 6,708 men.

FIGURE 17. Percentage of women by level of education
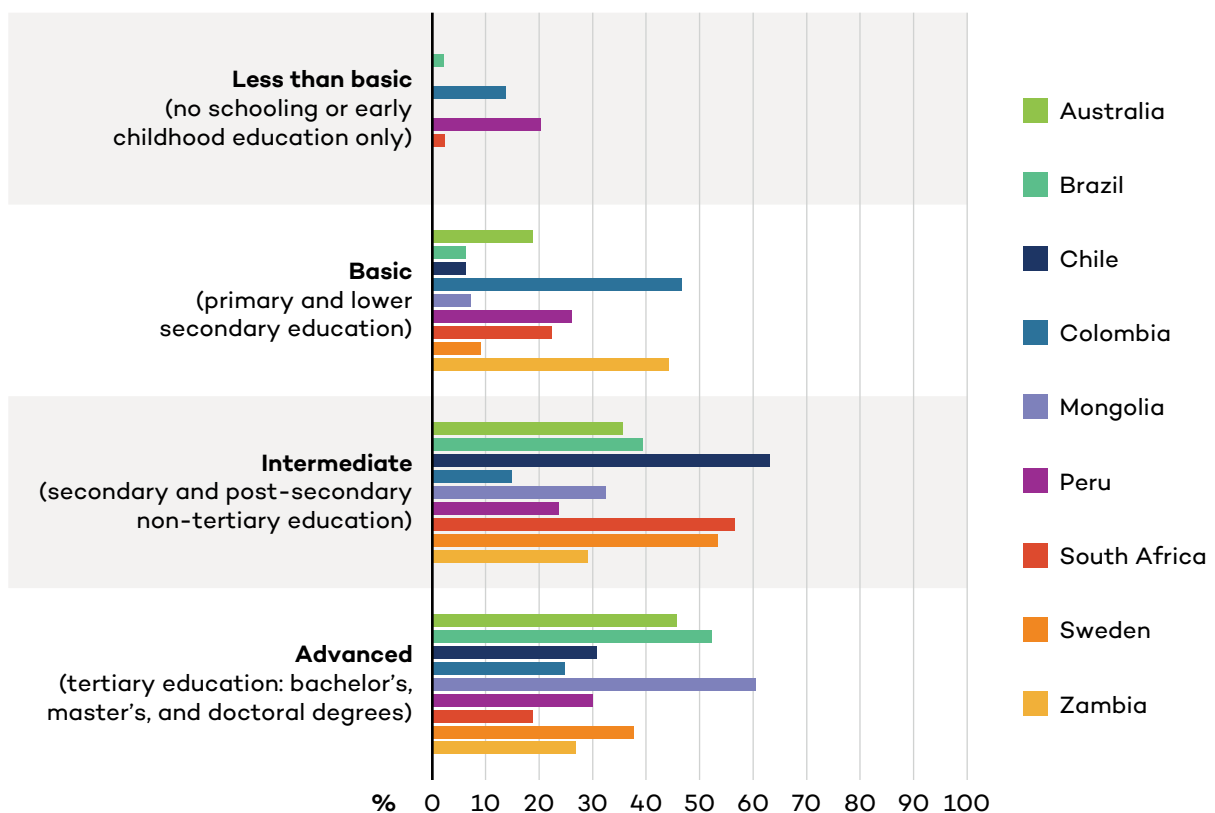
Source: Authors' calculations, based on ILO database, 2016–2020.

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12 There was no ILO data available for Ghana after 2017. ILO data for Argentina was discarded due to its inaccurate sample.

FIGURE 18. Country comparison of female education by level
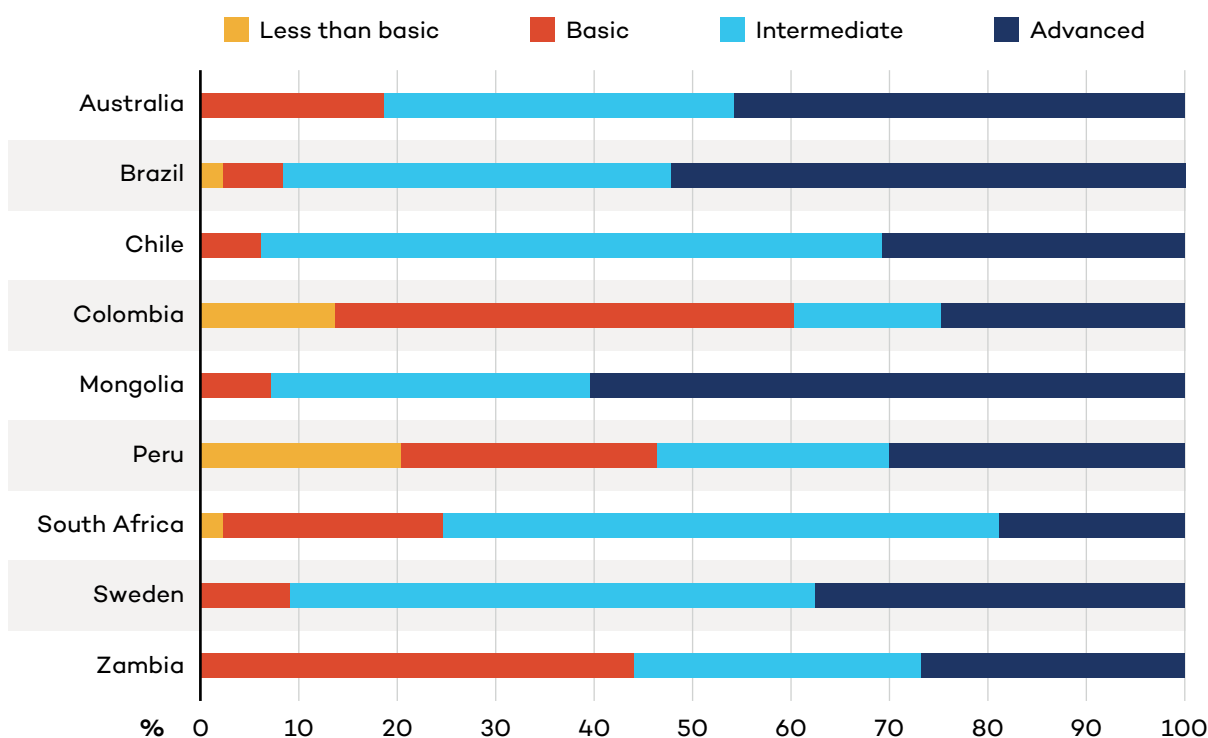
Source: Authors' calculations, based on ILO database, 2016–2020.

The case of Brazil (IGF, 2022b) stands out, with the widest difference in educational attainment between men and women employed in mining. On average, between 2009–2019, the proportion of women employees with advanced levels of education (57%) was triple that of men (18%). This is explained because various functions that are traditionally occupied by men, such as maintenance and repair, and production of industrial goods and services, generally require an intermediate level of education. On average, 97% of women and 91% of men in managerial positions had higher education degrees.

Sweden, Canada, and Mongolia showed similar trends. In Sweden, 35% of women compared to 13% of men had an advanced level of education (IGF, 2022i). In Canada, women have the highest representation in roles that tend to require a university education, such as professional and managerial occupations (IGF, 2022c). In Mongolia, 47% of women in mining had advanced education degrees in 2020 compared to 37% of men, contributing to their relatively higher presence in managerial roles. The country with the smallest difference was South Africa (IGF, 2022h), where 20% of women had an advanced level of education compared to 13% of men.

Trend 2: Despite their higher educational attainment, women have fewer technical and vocational qualifications.

While women in mining generally have more advanced education than men, it was observed that they had fewer technical and vocational qualifications than men. This is an important barrier to the recruitment of women for core mining activities, which are more labour intensive, generally requiring mining-specific skills.

HIGHLIGHT #12: HOW DOES THE EDUCATION SYSTEM WORK IN AUSTRALIA?[13]

FIGURE 19. Structure of the education system in Australia
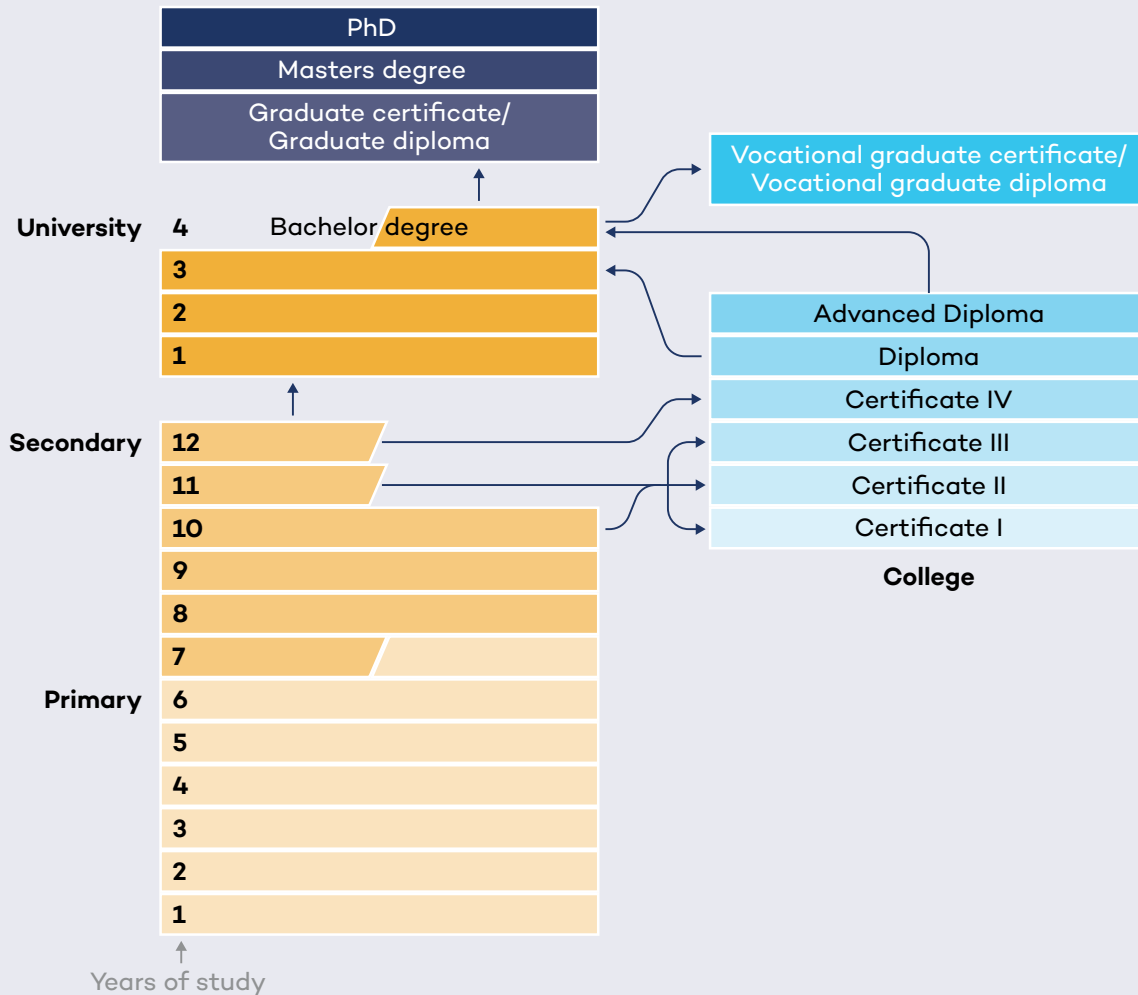
Source: Authors' diagram.

The Australian case can help us better understand gender-specific skills challenges in the large-scale mining sector. The baseline report found that in 2016, 25% of women working in the mining sector had university degrees, followed by 20% with upper secondary-level education. While tertiary education is mostly associated with better-paying jobs and career prospects, 40% of the mining workforce in Australia has college certificates (i.e. Certificate I to IV), which provide them with the technical training required to become technicians, trades workers, machine operators and drivers (IGF, 2022a). It was found that women had low participation rates in technical training and hence, were less present in occupations requiring those skills. This indicates that more women in Australia would need to acquire Certificate I to IV qualifications to increase their chances of employment in technical occupations.

13 Australia was selected as a highlight due to the availability of data.

The trend toward a highly gendered type of education was also observed in other countries, including in advanced economies like Canada or Sweden. In Sweden (IGF, 2022i), the upper secondary programs—from which the mining and metal industry predominately recruits—are all strongly dominated by men. These include programs in vehicle and transport (82% men), industrial technology (89%), building and construction (91%), and electricity and energy (97%). Women are ahead in programs such as business and administration (53%), natural resource use (68%), and health and social care (75%).

In Brazil (IGF, 2022b) in 2018, only 8% of high school graduates were enrolled in vocational programs (OECD average is 40%). Of these, more than half were women. Compared to OECD countries, this has positioned Brazil among the five countries with the highest female participation in this type of training. However, this provides a very small pool of trained labour, considering the small portion of students enrolled in this type of program.

Similarly, in Chile, occupations that recorded the lowest female participation rates were those requiring technical training, such as mechanical (2% of female participation); electrical maintenance (4%), maintenance supervision (4%), extraction supervision (6%), operation of fixed equipment (6%), professional maintenance (7%), and operation of mobile equipment (8%). Between 2012 and 2019, there has however been some progress in women's participation in most of these occupations. Projections for the future forecast that by 2028, the highest demand for labour will be in occupations such as mechanical maintenance, operation of mobile equipment, and operation of fixed equipment. Given the current low female participation rate in those occupations, women are less likely to benefit from future opportunities if the status quo in terms of training persists (IGF, 2022d).

Likewise, in Ghana (IGF, 2022e), opportunities for women to work in technical fields in large-scale mining are hampered by the lack of secondary, vocational, and technical qualifications which are obtained by only 12.7% of females compared to 21.5% of males at the national level.

One notable exception to the underrepresentation of women in technical and vocational training is South Africa (IGF, 2022h), where a higher share of female enrolment is observed in the post-secondary education and training system, which is composed of universities, TVET colleges, and community education and training (CET) colleges.[14] In CET colleges, the level of male participation is significantly lower than that of women, a trend that has been consistent over a 10-year period. In 2019, the female enrolment rate was 40% higher in TVET colleges and 50% higher in universities.

One would expect that the high female participation and success rates in post-secondary education and training would eventually narrow female underrepresentation in the mining workforce in South Africa. However, the country baseline report did not find any evidence of this happening. Instead, it found that despite being more successful and better represented than men in the post-secondary education and training system, there still appears to be a slow entry into STEM careers such as mining.

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14 CET colleges target post-school youth and adults who wish to further improve their skills for employability and/or progression to opportunities in the TVET colleges and university education. TVET colleges offer two main qualification types: the National Certificate (Vocational) and the National Technical Education Diploma (IGF, 2022h).

Trend 3: Women are less likely to receive on-the-job training and apprenticeship opportunities than men.

Traineeship and apprenticeship are often conducted in workplaces, which, in the mining case, are mainly in remote areas. This fact makes it harder for women to participate in traineeships and apprenticeships. In Australia, the vast majority of traineeship and apprenticeship commencements took place in very remote, remote, or outer regional areas. As demonstrated earlier, since women can be more often concentrated in urban settings, this could be a barrier to their ongoing professional development. Between 2016 and 2019, the share of women in commencements for mining apprenticeship and traineeship was 17%. That number rose to 24% in 2020. The increase in 2020 could be explained by the need for many employees to reskill and retrain due to new training requirements brought about by the COVID-19 pandemic (IGF, 2022a).

What remained consistent was the fluctuation of trainees and apprentices across age groups, which followed a U-shaped pattern. Women in the age group 20–29 received more training and apprenticeship opportunities, followed by a decrease in subsequent age groups before picking up in the age group 50–59, with the highest share being in the age group 60 and up. This indicates that women might have more availability for training and apprenticeship in either their early or late ages.

In Mongolia (IGF, 2022f), in 2021, a total of 22,187 employees were involved in vocational training, of which 20.5% were women. According to the Mongolia baseline report, training and employee skill development planning is very general because companies often do not consider gender-related needs of the professional development training, refresher training, and capacity building. Besides, the low number of women involved in the training can be directly related to the small number of female employees among the total number of employees in the companies.

In Ghana (IGF, 2022e), in turn, the baseline report showed the example of a company to illustrate the low participation of female employees in training and apprenticeship. In both 2019 and 2020, women accounted for only 9% and 4% of trainees and apprentices, even though the average number of training hours fluctuated between genders.

Trend 4: Women are underrepresented in STEM education programs.

Like technical training, most countries see a much lower representation of women in STEM and STEM-related programs.

In Brazil, 32% of students completing courses in engineering, manufacturing, and construction were women, representing the smallest disparity between men and women in this area, compared to OECD countries. However, women predominated in training in the field of health and care and services (IGF, 2022b).

In 2018, more than half of all Brazilian students enrolled in higher education were women. However, only 30% of all STEM students were women, while 63% of non-STEM students were women. Gender inequality was more pronounced in IT and engineering, where women represented less than 8% of the total students in IT, and 10% in mechanical engineering. There is, therefore, significant potential to improve the participation of women in STEM courses at universities, mainly in professions that might be relevant in occupations needed for the future of mining, such as IT.

The low participation of women in STEM-related education was also observed in Chile (IGF, 2022d). In 2020, practically all fields of engineering courses at university recorded less than half female participation. For instance, women made up less than 10% of graduates in the fields of electronic civil engineering, mechanical engineering, and electrical engineering. In engineering programs specific to mining (civil engineering in mining, civil, and metallurgical engineering, and mining and metallurgy engineering) women represented around 20% of graduates in 2020.

In South Africa, as elsewhere, there seems to be a correlation between the low participation of women in STEM education and their underrepresentation in some occupations in large-scale mining. The country scores below the global average of 30% of women pursuing STEM careers, although it is still leading in sub-Saharan Africa.

Mongolia stands out with a slightly better representation of women in STEM courses. Among the total number of university and college graduates, 63.7% were female students. Women were 54.7% of graduates from natural sciences, mathematics, and statistics, 29.9% from engineering, manufacturing and design, and 27.8% in ICT.

HIGHLIGHT #13: MONGOLIA ESTABLISHED DEDICATED POLICIES AND PROGRAMS TO INCREASE REPRESENTATION OF WOMEN IN STEM

The case of Mongolia (IGF, 2022f) presented a particular scenario that showcases the impact that the gender-responsive policies can make. The Ministry of Mining and Heavy Industry, the Ministry of Education, Science and Culture, and universities collaboratively work to develop and implement human resource policies that focus on training engineering professionals and increasing women's participation in the mining sector in line with the government's gender strategy. The German–Mongolian Institute for Resource and Technology is one of the first training institutions to focus on this area, according to the report. It seeks to keep at least 30% of female enrollees in the engineering, technical, and technology profession programs. In terms of promoting technical vocational education, the Polytechnic College of Umnugovi Aimag is attempting to enrol more female students in technical professions. In the 2017–2018 academic year, 30% of the 153 students were women in technical professions. This demonstrates that concerted efforts with a clear vision to make gender equality a core priority lead to structural change.

In Sweden, patterns of gender segregation are less evident in overall higher education. Both men and women study natural sciences, mathematics, and ICT, but women predominate in study areas relating to biology and environmental sciences (68% of graduates) and physics, chemistry, and Earth sciences (49%), whereas men have a higher enrolment in mathematics and other natural sciences (65%) and ICTs (63%). In the field of engineering, manufacturing, and construction, women are most found in materials and manufacturing (61%), while men predominate in engineering (68%). It is important to note that women's representation in engineering, manufacturing, and construction studies increased by 8% over 10 years, pointing to positive changes for women in future of the labour market.

Trend 5: Women with science, technologies, engineering, and mathematics degrees prefer other industries over mining.

Many country reports found that there was a disconnect between the proportion of women graduating with STEM and STEM-related education at the national level and the share of women working in mining occupations requiring such skills. This indicates that women with STEM educations either prefer not to work in the mining sector or do not get employed in mining.

In Australia, despite the increase in the STEM-qualified female workforce at the national level, they were not proportionately represented in mining, where STEM-related occupations were still dominated by men. A report released in 2020 found a 14% increase in vocational education and training (VET)[15] STEM-qualified female labour force and a 74% increase in the university STEM-qualified female workforce between 2006 and 2016 (IGF, 2022a). This seems to confirm that while there are qualified Australian women available in the labour market, they seem to encounter other types of barriers to entering the main mining occupations.

In Canada, too, a lower representation of women in the mining sector is observed, both by skill levels and by STEM education, compared to other economic sectors (IGF, 2022c). These findings indicate that, somehow, Canadian women with a STEM education prefer to work in other industries instead of joining the mining sector.

An important issue to consider in understanding the mismatch in women's participation in mining jobs is the field of education they tend to take. In Australia, women have a higher participation rate (above 20%) in occupations that do not require STEM qualifications (IGF, 2022a). One notable exception is clerical and support-related occupations, in which 21% of women have STEM qualifications. Although this appears to be unique to Australia, it highlights the critical challenge of the underutilization of women and therefore the need to address all aspects involving gender exclusion in the work environment.

Another study in Australia surveying women in mines highlighted that psychosocial factors involving lifestyle, sense of community, availability of facilities such as housing and schools, anonymity, and independence were reasons why women with STEM qualifications chose not to work in remote mines. Other women in the study preferred to remain in roles lower than their educational qualification, deciding to find satisfaction through making a difference in office-based roles (IGF, 2022a). This indicates that women with STEM degrees and education might prefer other industries or occupations with fewer gender biases and barriers to employment.

HIGHLIGHT #14: WOMEN GRADUATES FROM THE MONGOLIA'S SCHOOL OF GEOLOGY AND MINING DO NOT CHOOSE MINING.

In Mongolia, 80% of all male graduates from the Geology and Mining School of Mongolian University of Science and Technology work in the mining sector, while 20% to 30% of women graduates work in the sector. Most of these women are from the community where the mine operates or are very interested in working in the mining sector. The rest of the female graduates work in banks, other financial institutions, insurance companies, and research institutes. The Mongolia study reported that women chose other sectors because of perceptions from their families that mining is not appropriate for them or that they are too young to work in the sector.

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15 In Australia, VET is study that offers you the opportunity to learn specific and practical job skills.

Trend 6: Women within certain branches of STEM are relatively more represented in the mining sector.

The findings from the baseline countries highlight that female STEM graduates working in the mining sector are mostly concentrated in certain educational fields such as environmental engineering, geology, geographic information systems, and data processing.

In Australia, for example, there is a relatively greater employment share (26%) of women with qualification in the fields of natural and physical sciences (such as geology) compared to the overall female participation in the sector (18%). This is followed by a 20% share of women with qualifications in agricultural, environmental, and related fields which finds them in occupations as environmental specialists and superintendents, conservation officers, and producers of fresh produce and poultry.

Similarly, in Chile, in 2019, female geologists represented 23% of all geologists, which is significantly above the overall participation of women in the mining workforce, which is roughly 8%. In Canada, women tend to be better represented in fields such as geoscience and less represented in the trades.

This trend could be related to the increasing demand for certain occupations that have a higher supply of female labour compared to others. For example, South African mining is more processing intensive and includes higher levels of planning, exploration services, geographic information systems analysis, analytical, data processing, financing functions, drilling, surveying, and so on. As reported by interviews with experts in Peru (IGF, 2022g), with the increase in the corporate focus on ESG requirements, careers linked to environmental engineering—where workers are involved mainly in the evaluation of the mining impact activity in the communities—are in higher demand. This trend is also in line with the stock of qualified university graduates. For example, in Chile, there has been an upward trend in the share of female graduates in geology and risk prevention engineering, which could contribute to the higher representation of women in occupations that require such degrees.

Assumption 6: Women quit large-scale mining at a younger age.

The retention rate of women in the large-scale mining sector is another challenge impeding their equal participation in the mining workforce. In a sector where attracting women is a structural challenge, retaining and promoting women who are already in the sector are key strategies to achieve gender parity.

Trend 1: The "leaky pipeline" is not a myth.

Data from most countries confirm that women tend to drop out of mining jobs at an earlier stage in their careers compared to men. As a result, the large-scale mining workforce is predominantly composed of middle-aged men (30–50 years).

Figure 20 provides a sex breakdown by countries across age groups based on the country reports. While there are variations across countries, we can see that the representation of women in mining starts to fall for many countries between the age bracket 35–44. Those numbers dwindle after the age of 45 more quickly compared to the change in the male employment, which is characterized by a smoother decline after the age of 45.

FIGURE 20. Percentage of women and men employed by sex and age for Brazil, Chile, Colombia, Ghana, Mongolia, Peru, South Africa, and Sweden
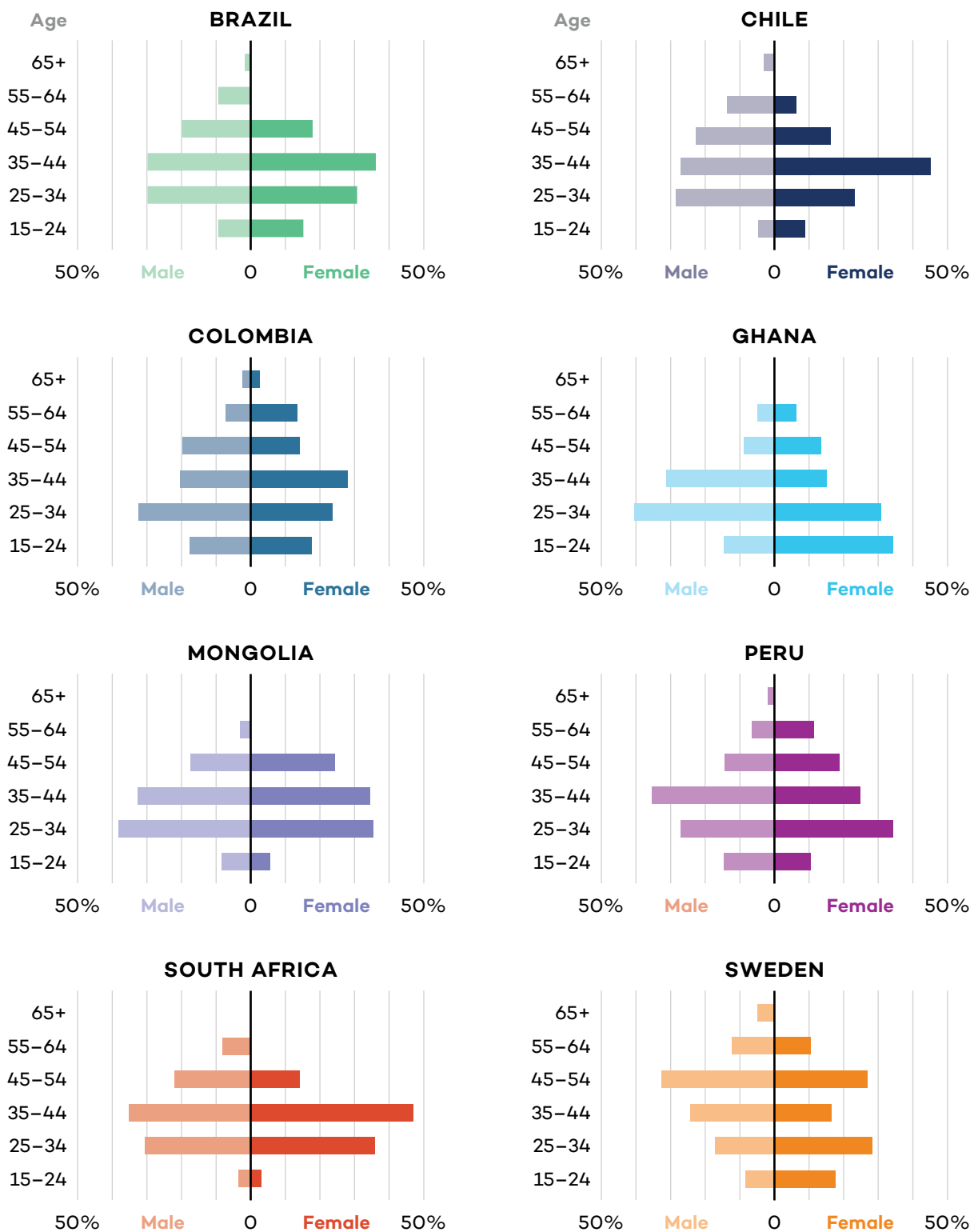
Source: Authors' calculations, based on ILO database, (2018), except Chile and Ghana (2017).

Nuances across countries are observed in these figures. Notably, women make up around 40% or more of the 35–44 age group in Chile, South Africa, and Brazil. In all countries (except for Sweden and Mongolia) there is a steep decline of representation of women between the age groups 35–44 and 45–54, indicating a "leaky pipeline." In Mongolia, the decline is noticeable after the age of 54.

Country baseline studies provide further insight into national patterns of women leaving the mining sector as they grow older. In Australia (IGF, 2022a), 21% of all employees under the age of 30 are women, and that number decreases drastically with age. The presence of women in the age groups 50–59 and 60–69 years was 12% and 11%, respectively.

In Brazil, the bulk of employees (i.e., 64% of men and 58% of women) working in the mining sector are concentrated in the age bracket of 30–49 years. The second group of workers by age category are younger employees aged between 18 and 29 years, who accounted for 38 of all female employees and 27% of male employees. Proportionally, one can observe that female mining employees in Brazil are under the age of 49.

In South Africa, men aged 25–34 made up 22% of the total mining workforce, while women accounted for only 6%. With time, the gap widened: in the age bracket between 35–44 years of age, men made up 31% of the total workforce, while the proportion of women remained the same at only 6%.

In both Brazil and South Africa, the decline in women's share of employment is even steeper in the older age bracket. In Brazil, women represented 58% of all workers in the 30–49 age category and only 3% of all workers aged 50 years and above. In South Africa, although the gap is relatively smaller, it still seems that half of women in the age bracket 35–44 simply disappear (roughly twice the drop-off rate of men), while most of the remainder disappear above 55 years of age.

Peru shows a trend similar to Brazil's, with a significant share of young women employees, with 58% of all female employees concentrated in the age group of 15–34 years, compared to 41% of men (IGF, 2022g). There is a significant decrease in the number of older female workers in Peru, going from 32% of all workers in the age group 35–44 to 9% for those aged 45–54. Interestingly, there were no women employed older than 54.

The decrease in older female employees was also noted in Mongolia (IGF, 2022f). While the number of male employees remained almost the same throughout the age groups, the study noted an 11.6% drop between the age brackets 45–54 and 55–64.

Sweden has a similar trend. Dividing women and men into three different age groups, the data show that the industry is particularly dominated by older men. Men aged 44–64 made up 38% of the workforce in 2019. While the number of men employed increases with age, the number of women decreases in the age groups 30–44 and 45–64. However, there have been incremental improvements over time. In 2014, the proportion of older men was greater and that of women lower. In 5 years, the share of female employees aged 30–44 and 45–64 years increased by 3% and 2%, respectively.

Trend 2: Women's dropping out from the sector is related to the occupations and the type of work they perform.

Looking at the gender breakdown of mining workforce by age and by occupation, some country baseline studies found that female workers in older age brackets tend to be concentrated in clerical support functions, while younger women are more concentrated in occupations like craft and trade work, and plant and machine operations.

In Australia, breaking down occupations according to age brackets shows that the steepest decline is for female managers, who made up 39% of all managerial positions when they are under 30 (IGF, 2022a). Their share decreases steeply (to less than 10%) at the age bracket of 50 years and above. However, their share remains steady in clerical and administrative positions, going from 66% at 30–39 years to 62% between 60–69 years.

Similarly, in Sweden data from 2019 highlighted that women in older age groups (45–64 years) mainly held clerical support occupations (IGF, 2022i). Younger women (16–29 years) mostly occupied positions as craft and related trades workers, plant and machine operators, and elementary occupations. It was found that men between 45–64 years old were more represented in all occupations except clerical support, especially the managerial level.

In Brazil, consistent with the findings above, younger women (18–29 years) were proportionally more concentrated in craft and trade work (IGF, 2022b). In maintenance and repair, 58% of female employees were in the younger age bracket; in the production of industrial goods and services, the proportion was 47% and 37%, respectively. The female dropout rate was notable for managers and professionals, representing 72% fewer women in the age group 50–64 compared to the previous age bracket. These two occupations require higher education levels, and they had the highest proportion of women in the most advanced age groups.

HIGHLIGHT #15: BRAZIL'S EXCEPTION: WOMEN IN CLERICAL SUPPORT POSITIONS ARE NOT NECESSARILY RETAINED.

Unlike other countries, clerical support positions did not particularly retain Brazilian women over 50. Instead, this occupational category mostly employed younger workers, aged between 18 and 29 (40%). In the case of the older age brackets, managerial positions represented the higher share of Brazilian women (10%) in this age group. The country report could not provide an explanation for this phenomenon.

Trend 3: Women leave mining for a variety of reasons, including non-inclusive working conditions and lack of growth.

Women leave the mining workforce for a variety of reasons, depending on their contexts and situations. As explained in detail under Assumption 3, working conditions often do not consider the specific needs of women. The lack of appropriate prenatal and parental policies and support can pose a challenge to women in balancing their private and professional lives. Care responsibilities might also impede women's career growth in the sector. This issue is also influenced by social conventions, depending on cultural values and, therefore, different across contexts.

For instance, the Australia report directly links having a child with women leaving the mining sector, as "nearly one-third (30%) of VET qualified females and nearly one-fifth (19%) of university qualified females, who had a STEM qualification and were working full time in 2011, left the labour force after having a child" (The Office of the Chief Economist, 2020, p. 198 cited in IGF, 2022a). Many women considered it difficult to return to the mining sector after their parental leave because there was no mechanism to support their care for children while working full time in remote mining locations (IGF, 2022a). A 2019 women's report card conducted by the Western Australian Department of Communities revealed that 57% of women identified poor access to childcare in remote locations as a barrier to their participation in the sector (IGF, 2022a).

Similarly, in a survey conducted in Ghana among women working in apparel, mining, and mobile telecommunications (IGF, 2022e), the majority of respondents identified the lack of a childcare facility at their workplace or the lack of company support to pay for childcare as the main challenges preventing continued employment after maternity leave.

 In addition to the challenging working conditions, one other key factor that drives women employees out of the mining workforce is the discriminatory work culture. The 2021 McKinsey Report (2021b) revealed two main factors that are driving women out of mining: the work ceases to be interesting and there is a perceived lack of advancement. In this sense, limited growth opportunities, low remuneration compared to men, and incompatible skill sets are all reasons that may explain the leaky pipeline.

Findings from the South Africa report (IGF, 2022h) appear to corroborate the argument that the workplace culture is not conducive to women's employment. In a survey of 452 women (most of them middle-aged permanent employees at a mine), respondents identified similar barriers to their access, retention, and promotion: preferential treatment of male counterparts for promotions, bias against women working in mining, the perception that women get promoted to fulfill quotas instead of merit, the perception that women aren't physically or professionally qualified, cultural bias about women's roles at home and at work, and lack of clear commitment toward equality in the workplace.

HIGHLIGHT #16: EARLY RETIREMENT MIGHT IMPACT WOMEN'S REPRESENTATION IN THE WORKFORCE IN OLDER AGE GROUPS.

It is worth noting that one of the reasons for women's drop-off rate from large-scale mining may be related to the regulatory context for social security. In Mongolia, for instance, women can retire at the age of 55 or under. Peru allows for early retirement for women starting from age 50, provided that they meet certain requirements. In Colombia, the retirement age for women is 57 (OECD, 2021).

Assumption 7: The gender pay gap stubbornly persists in the mining workforce.

One of the most common assumptions used to explain the attraction, retention, and career development challenge for women in the mining sector has been the persistence of a significant gender pay gap. The gender pay gap and lack of career advancement opportunities are considered among the key reasons to explain why women drop out of the mining workforce at a higher rate than men (McKinsey, 2021b).

Trend 1: Women employees in large-scale mining earn lower wages.

Various country baseline studies pointed out that wages and salaries in the large-scale mining sector were on average higher than in other economic sectors. In Chile (IGF, 2022d), average salaries in the large-scale mining sector are almost three times higher than in other economic sectors. In Mongolia, the average salary is twice that of other sectors. In Ghana (IGF, 2022e) the extractive sector pays significantly higher wages (about 10 times higher) than other sectors.

However, despite the relatively good wages mining can provide, the gender pay gap is significant in the sector. In Australia (IGF, 2022a), women earn 83% of men's salaries in the large-scale mining sector. Over an 11-year period, the pay gap discrepancy oscillated, reaching its lowest historical figure of 13% in 2019. However, from 2019 to 2021, the pay gap widened again, suggesting that structural challenges to reversing this discrimination remained unsuccessful.

Additional data show that men and women might not have equal access to high-paying jobs in mining. In Australia, the ratio of female to male mining employees decreased as weekly earnings increased, showing a decline in the pool of women earning higher salaries relative to men. Illustrative of this, women make up only 9% of the highest earning bracket, whereas they make up 42% and 47% of employees in the lowest two brackets, which are, incidentally, below the weekly minimum wage. This confirms earlier trends that Australian women have been unable to access or stay in higher- and better-paid positions in the mining industry despite their qualifications.

The report also pointed out the existence of a gender pay gap in Canada (IGF, 2022c). From 2010 to 2020, women earned an average of 14.8% less per week than men in mining over this 10-year period. Another example is South Africa (IGF, 2022h), whose baseline report mentioned that the gender pay gap in the mining sector is at a ratio of 2 to 1. In Ghana, the report confirmed a gender pay gap related to the overall extractive sector, where women are found to be paid less than men doing the same job, with a median gender pay gap of 27.5% in 2013 (IGF, 2022e).

Trend 2: Women workers work fewer hours.

Data from the ILO provide a quick snapshot of the mean weekly average hours worked disaggregated by sex in large-scale mining. It shows that, on average, female mining employees worked fewer hours than their male counterparts.

FIGURE 21. Mean weekly hours worked by sex
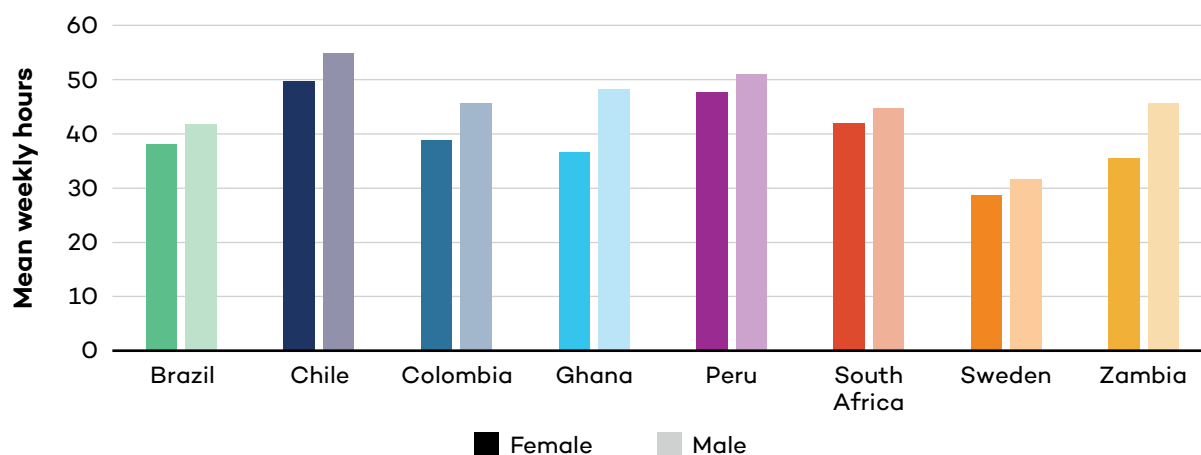
Source: Authors' calculations, based on ILO database, 2016–2020.

Several baseline studies confirmed the trends observed above. This was noted when examining women's weekly working hours in full-time jobs as well as the proportion of women working part time. Average wages are calculated on the basis of hours worked, and therefore contribute to the gender pay gap as labour markets reward those who are willing and able to work more hours. In the mining industry, the market mostly favours men.

In Canada, from 2010 to 2020, women in full-time mining jobs worked an average of 2.9 hours per week (6.5%) less than men (IGF, 2022c). Similarly, in Australia, women accounted for 67% of all part-time employees and 16% of the full-time employment in 2020/2021. The country (IGF, 2022a) recorded a slight increase in the overall employment of women, essentially part-time employment. As such, mining is ranked as one of the sectors in which women are in a relatively larger proportion to men in part-time employment. However, the total number of women working full time was larger than those working part time. This is the highest proportion compared to other economic sectors and could be because of the remoteness of mine sites, which makes it hard for women to work on a part-time basis.

Many country reports highlight that women opt for part-time jobs, which might be related to the expectations associated with unpaid reproductive labour and care work, and the need to balance out work and life. Often, reducing working time is one possible option for women to remain in the labour market rather than leaving it. Not having this flexibility could possibly explain the previously observed leaky pipeline.

However, more flexibility should not be a reason to justify the gender pay gap or confine women to lower-paid jobs. Sadly, in many instances, women opting for flexible work arrangements become less attractive for high-level positions, considering that these types of occupations often demand more working hours. This limits their growth opportunities within the company and affects their remuneration.

Trend 3: Despite their higher education, women still earn lower wages than men.

Some country reports examined the relationship between levels of education and average wages. It was found that despite having higher education attainment, women in large-scale mining still earn less than men.

In Brazil, women with advanced education earned, on average, 84% of men's wages (IGF, 2022b). In South Africa, qualified men's earnings are nearly double those of women who have the same, equivalent, or higher educational qualifications (IGF, 2022h). In occupations requiring lower skill levels, however, there was a narrower gap in wages between men and women.

In Australia, data from 2020 on all economic sectors highlighted a discrepancy in median weekly earnings at advanced levels of education (IGF, 2022a). A gender pay gap of 26% and 20% was noted between men and women with graduate and postgraduate degrees, respectively. There was a wider pay gap (36%) among employees with technical training (Certificate III/IV), a category of jobs in which female participation was low.

Trend 4: The gender pay gap is higher for better-paid occupations, in which women are less represented.

Another important factor that further exacerbates the overall gender pay gap is the overrepresentation of women in relatively low-paying occupations and their underrepresentation in higher-paid occupations (European Parliament, 2022).

In Brazil, there was a gender pay gap in all occupations except two, including in jobs traditionally held by women. For instance, in clerical support, women earned 94% of men's salary, and in mid-level technicians and professionals, the pay gap was 89% and 76%, respectively. Even within the group of managers, which experienced an increase in female participation in recent years and a strong presence of graduate women, female managers earned an average of 71% of men's pay in the same occupation (IGF, 2022b).

Women earned more than men in only two occupations, namely services and sales, where women earned 7% more than men, and in agriculture, forestry, hunting, and fisheries,[16] where women earned 57% more than men. While noteworthy (and significant for women working in those occupations), it must be noted that these jobs account for a very low share of total mining employment (2% and 0.04%), and therefore are not representative at the industry level.

In South Africa, results are slightly different (IGF, 2022h).[17] In 2020, male workers were better paid in all occupations with the exception of clerical support. This was especially true in the category of managers and professionals, where women earned 69% and 50% of men's salaries, respectively.

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16 According to the Brazilian report (IGF, 2022b), mining establishments reported the following activities under the occupation of agricultural, forestry, hunting, and fisheries: agricultural workers, workers in livestock, supervisors in forestry and fishing, forestry extractors, and agricultural mechanization workers.

17 The data has been supplemented with academic research on South Africa's general employment situation (Hill & Kohler, 2020), and it is not specific for mining.

In Australia, based on 2020 data for all economic sectors and considering the median weekly earnings, the highest gender pay gap was noted among machine operators and drivers (33% pay gap), and technicians and trades workers (32%) (IGF, 2022a). On the other hand, managers and sales workers had a relatively lower gender pay gap, both at 17% for median weekly earnings, followed by professionals, at 20%. Clerical support, in which women had a dominant presence, also showed a pay gap of 23%, with most women concentrated in the low weekly earnings range. A larger percentage of men were concentrated in the higher earning brackets for the same occupation. This results from women being more concentrated in lower levels of clerical support roles, which pay less than the higher levels, where men dominate. Here, women are not only in a low-paying occupation but also in the lowest salary ranges within it.

Mongolia showcased a particular scenario (IGF, 2022f). In 2020, women earned 3.3% more than men. However, a closer look at the salaries by occupation reveals that women received higher salaries than men in only one job category, effectively skewing the pay gap average. On the other hand, craft and related trades workers showed the greatest pay gap, with women earning 45% of the men's remuneration. In the occupation category managers and clerical support, women workers earned 62% and 79.5% of men's remuneration, respectively.

HIGHLIGHT #17: ZOOMING INTO SOUTH AFRICA'S GENDER PAY GAP REPORTED ACROSS ETHNIC GROUPS

South Africa reported the gender pay gap with an intersectional lens, looking at differences in ethnicity and race.[18] In 2020, the racial composition in the mining sector was largely composed of (Black) Africans, constituting 86% of the sector's employees, followed by Whites (11%), Coloured (3%) and Indians (1%).

Wage discrepancies were noted, in favour of White men compared to White women, with the former earning nearly twice as much. The gap was even wider when comparing White women and Black African and Coloured women, where White women earn three to four times the salary of their Black African and Coloured counterparts. The research concluded that Indian men and Black African women received the lowest remuneration.

Concluding Remarks

The aim of this chapter was to highlight, in a comparative way, the main data findings from the countries selected in *Women and the Mine of the Future: A Gender Analysis of Employment and Skills in the Large-Scale Mining Sector*. Overall, data collected from the 12 country reports confirmed some similarities in global trends, despite some notable nuances and differences, reflecting countries' specificities in terms of historical, socio-cultural, and economic conditions.

The data presented in this section clarifies some of the reasons behind the consistently—and persistently—low participation of women in the large-scale mining workforce. It provides nuanced and granular insights to uncover the path forward, with a view to improving the participation of women in the mining industry. The following chapter will explore changes in occupations over the past 10 years and any foreseeable changes in occupations in mining, specifically looking at the challenges and opportunities for women in this transition.

18 For South African Race terminology/categorization, see IGF, 2022h, p. 24.

2.0 Megatrends for the Future of Mining

Introduction

The large-scale mining sector is at crossroads,[19] driven by megatrends such as the swift adoption of disruptive technologies in mining operations, the exponential demand for minerals and metals critical for the energy transition, and the imperative to embrace urgent climate actions. While they will have significant implications on the industry's operational and organizational activities, importantly, they will profoundly modify working conditions and the demand for labour. It is important to unpack these megatrends carefully, to better understand how male and female mining employees could be impacted differently.

This chapter provides an overview of the main factors that are likely to challenge the mining labour force in the future, focusing on possible ways each trend may affect mining occupations. It specifically looks at opportunities and challenges to increase women's participation in the mining workforce given the trends observed in Chapter 1. To further answer the questions posed in this chapter, the second phase of the WMF project will map the gender-disaggregated changes in occupational structures and skills requirements needed for future jobs in large-scale mining.

However, a word of caution is necessary: the analysis provided in this chapter is based on the hypothesis that these trends will continue to drive changes in the mining sector, and it is therefore based on our best projections given the current dynamics. At this point, it is too early to make any authoritative conclusions as the dynamics at play are complex, fast changing, and subject to risks that are difficult to foresee.

This section examines two megatrends likely to have profound implications on the future of mining jobs: disruptive technologies and climate change and the energy transition. Each trend zooms into specific features that are likely to be determinant for the future of work,

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19 The changes that will be faced by the mining sector are part of the global dynamics the world is facing. For instance, demographic changes, such as rising population expected until the middle of the century in developing countries and growing middle classes, will further increase the demand for minerals and metals. Similarly, in more advanced countries, the ageing workforce will make it harder to attract talent and replace the skills being lost. In addition, geopolitical turbulences linked to the security of supply and access to raw materials are attracting companies that do not necessarily respect working conditions and fundamental principles and rights at work, including gender equality. These will impact the future of mining but are outside the scope of this study.

considering gendered implications on current occupations and skills that will likely still be relevant for the jobs of the future.

Trend 1: The rapid adoption of disruptive technologies and digital solutions is changing the landscape of mining occupations.

Technological change is a recurrent feature of modern development and is critical to constantly improving the productivity and efficiency of industries. In that regard, innovation is not new to mining and is constantly mobilized to overcome natural factors such as declining reserves, lower ore grades, deeper deposits, and geotechnical difficulties due to harder rocks, among others (IGF, 2021).

The successive waves of innovations led by the adoption of new and disruptive technologies are different from previous rounds of technological change. In recent years particularly, there has been an acceleration in the pace of technological adoption in the mining sector that is bringing systemic changes, making mines more sophisticated, leaner, and smarter. These changes have repercussions on the way mining operations and workers interact, creating more agile mining operations. More recently, the COVID-19 pandemic has further fast-tracked the digitization of certain tasks to allow workers to work remotely.

Disruptive Technologies Coming to the Large-Scale Mining Sector

The technologies referred to in this report are a suite of different types of innovations that are being deployed in many other sectors but work in concert together to improve the efficiency of mining operations (IGF, 2021). In its 2019 *Technology Impacts Review*, the IGF mapped key emerging technology trends that are being developed and adopted in large-scale mining operations. These can be classified into four broad categories:

1. **The deployment of sophisticated hardware and machines embedded with artificial intelligence,** meant to boost the efficiency of mining operations. Examples include non-humanoid robotics, automated plants and machinery, automated vehicles and so on.

2. **The use of smaller connected devices** which are enablers of digitization, and which provide an interface between human intelligence and artificial intelligence. Examples include uncrewed aerial vehicles (such as drones), sensor technologies, connected wearables, GPS etc.

3. **Network architectures and software technologies** that support the first two types of technologies. They collect, analyze, and integrate large amounts of data in real time that are shared through high-speed connectivity, allowing information to be shared and processed instantly. Examples include virtual reality and digital twin interfaces; machine learning, advanced analytics, access to 5G architecture; the Internet of Things (IoT); cloud computing and so on.

4. **Technologies that are aimed at improving mining processes** notably to address environmental challenges and improve sustainability of operations. Those technologies cut across various opportunities. Examples include (i) the development of new mineral ore-processing technologies; (ii) improved waste and tailings management techniques to improve mineral recovery; (iii) water- and energy-saving technologies; and the adoption of clean tech, such as electric vehicles. These are particularly important to mitigate the impact of mining on the environment and to foster energy transition away from fossil fuel-powered operations.

In its *Future of Jobs 2020 Report*, the World Economic Forum (WEF, 2020) provides further insights about the pace of adoption, notably regarding the technologies that are most likely to be adopted by 2025. As shown in Figure 22, companies surveyed by the WEF broadly confirmed what was observed by the IGF Technology Impact Review.

FIGURE 22. Technologies likely to be adopted by 2025 (by share of companies surveyed)

90%
IoT & connected devices

90%
Big data analytics

83%
Encryption & cybersecurity

76%
Text, image & voice procesing

57%
Virtual reality

WHAT'S COMING

90%
Non-humanoid robotics & connected wearables

87%
Cloud computing

76%
A.I. (ML, neural networks)

62%
E-commerce and digital trade

57%
Power storage and generation
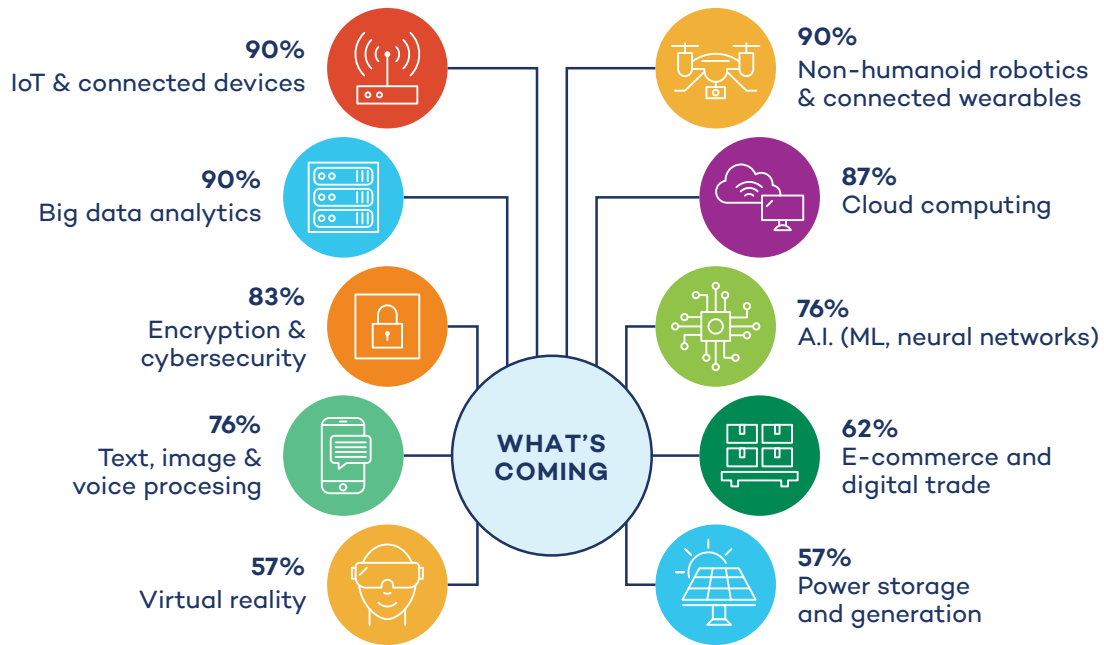
Source: Authors, adapted from WEF, 2020,

Given the continuous innovation and rapid breakthroughs in technologies, the mining industry cannot predict with certainty what the future will look like over the next few decades. However, what is clear is that regardless of the types of technologies embraced, the future will be digital, more mechanized, and highly connected.

While technologies are generally gender blind, mining occupations are not, and neither are the social contexts in which new technologies are introduced. It is important to highlight that the pace and breadth of technological adoption in the large-scale mining sector will vary within and across countries, with ripple effects on mining occupations that will reflect specific contexts. For instance, laws and policies in place, such as local employment requirements, may affect the choice of technological adoption and therefore the number and types of jobs that mines of the future will require.

Within countries, almost every mine is unique, determined by specific geological features. The geographical location of mine sites, the types of mining activities (i.e., whether mining is conducted on surface, underground, or in ultra-deep settings); and the types of mineral ores being mined will all affect the types of technologies that can be adopted, with resulting implications for mining occupations. Differences across countries are further explained in Feature 4.

Feature 1: Disruptive technologies and likely changes across occupations

Changes in mining technologies are affecting the types of occupations and employment opportunities in large-scale mining in several ways (IGF, 2021; ILO, 2018; WEF, 2020). Mines of the future are arguably going to be smarter, digital, leaner, and cleaner. Uptake of different technologies is highly context specific. These technologies will have varying impacts across countries and across the sizes, ages, and types of mining operations. Table 5 provides a simplified overview of the key features of future mines, with some examples of relevant technologies.

First, leaner mine structures that result from labour-saving technologies are expected to make some tasks[20] (and therefore some occupations) redundant, and thus reduce the employment intensity of some categories of jobs—the so-called displacement effect (IGF, 2021). A survey involving c-suite executives from mining companies that collectively represent more than 7.7 million employees worldwide revealed that a skills gap would be a major issue in the adoption of new technologies and that an average of 48% of existing employees would require reskilling/upskilling in the next 4 years (ICMM, 2021).

As Figure 22 showed, automated machinery and related digital technologies embedded in devices, data analytics, and connected infrastructures were ranked highly by the mining companies surveyed, indicating greater levels of sophistication of mining operations. Numbers are hard to predict with certainty, but the WEF report (2020) estimates that close to 20% of employment in large-scale mining could be displaced by 2025 due to the automation of some mining tasks.

Another concerning highlight is the increasing digitalization of current administrative tasks, such as machine learning for image, text and voice recognition and interpretation, or the adoption of new digital tools, such as blockchain technologies and digital trade, which may have significant impact on jobs most often occupied by women.

Second, features highlighted in Table 5 imply that many occupations will be restructured, redesigned, or modernized, as some technologies are meant to improve the efficiency of operations and productivity of workers. Those types of technologies will require different skill sets, and so there will be a need to upskill the workers to improve performance. Given the comparatively limited access for women to on-the-job training programs and vocational/lifelong learning opportunities, as showcased in Chapter 1, this trend can easily negatively impact women's ability to meet skills demand unless specific attention is paid.

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20 It is important to note that tasks—more than occupations—are likely to be disrupted (Pagés, 2019). Not all tasks within an occupation are equally automatable, but some technologies will completely change the nature of certain tasks and the associated skills and competencies requirements needed to perform specific tasks.

TABLE 5. Simplified overview of mines of the future and foreseen impacts on the labour force

Features of future mines	Characteristics	Examples of types of technologies
Digitalization	Mining operations are connected, productivity is enhanced, and decision making is more effective, happening in real time.	• Connected wearables • Satellite imagery and GPS • Uncrewed aerial vehicles • High-speed Internet connectivity (5G)
Smart mining	Highly sophisticated machinery, embedded with artificial intelligence makes mining operations more efficient and precise.	• Powered by artificial intelligence (machine learning, neural networks) • Use of big data analytics and quantum computing • Augmented/Virtual reality • Digital twins • IoT and cloud computing • Robotics, automated processes
Lean structures and remotely controlled	Organizational structures are leaner; operations are piloted from remote locations; activities can be carried out on a continuous basis.	• Remote control systems • Distributed ledger technologies (blockchains) • Digital trade
Decarbonization	Technologies aimed at reducing the carbon footprint of mining companies.	• Electromobility • Renewable energy and power storage • Water-saving technologies

Source: Authors, adapted from IGF, 2019 and 2021.

Third, even if some tasks are fully automated, jobs may not completely disappear, as some tasks are likely to remain critical to properly set up parameters and ensure the seamless functioning of machines. Human presence will remain vital to intervene in case of an emergency breakdown (McKinsey Global Institute, 2018). It is understood that reskilling and upskilling would be central to facilitating the transition to new occupations.

Fourth, other technologies will create new occupations that were previously not considered as mining jobs, to use, run, and supervise the new devices—the so-called skill-complementarity effect. It is not yet known how women will perform in other sectors, where such types of occupations are present and address the skills needs and gaps accordingly.

Fifth, very sophisticated technologies, such as those highlighted in Table 5, will require highly specialized skills, many of which are in new fields that are not present in many countries, in particular in developing countries. The challenge for women, already facing a scientific skills deficit, is likely to be more significant.

The South Africa country study provided some insight into the impacts of disruptive technologies on women's participation in the mining workforce and the upskilling requirements that come with the change in technologies. Responses to the survey question, "How has technology changed, enabled, or increased women's participation in mining?" included comments regarding the ability to work from home and remotely, having access to mine design software, geological modelling software, 4IR job training options, and greater female participation as manual labour is replaced by machine labour. A large percentage indicated that a high level of skill and competency in technology is required for performing their current job. Innovation is key to success, and job satisfaction has become a driver for many women in the workplace.

Feature 2: Disruptive technologies, skills, and gender pay gaps

The level of risk of workers displacement due to disruptive technologies is likely to differ across occupations and skills levels (Gibbs, 2017; IGF, 2021; Manyika, 2017). This is expected to have an impact on wages and salaries, and may therefore further exacerbate the gender pay gap.

FIGURE 23. Risks of occupational displacement are impacted by skills levels
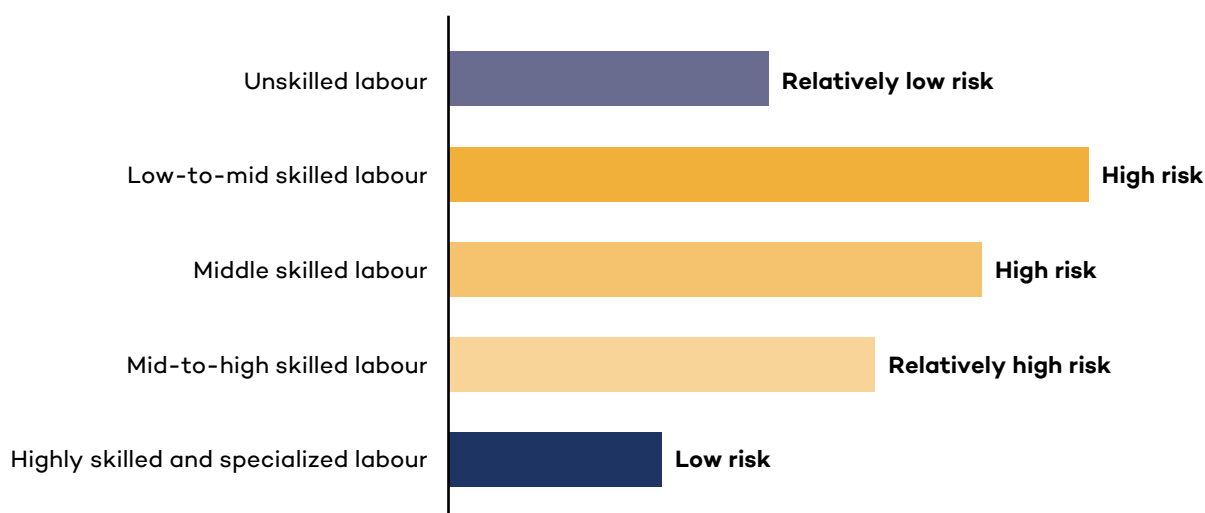
Source: Authors, adapted from IGF, 2021.

As observed in Figure 23, **certain tasks performed by unskilled labour may be less at risk of displacement.** In fact, wages associated with elementary occupations are generally low, and therefore mining companies may not necessarily prioritize their replacements with costly technologies. Furthermore, some elementary occupations, such as food preparation assistants, cleaners, and helpers, may not be replaceable by machines because of the human services associated with them. In general, the gender pay gap tends to be lower for unskilled occupations due to lower wages and poorer work conditions associated with them, as detailed in Chapter 1. Future demand and wages for such types of occupations may therefore not change significantly, but this won't necessarily imply better (or even good) prospects for women in these occupations.

Similarly, very highly skilled and specialized labour, such as mechatronics engineers, geophysical engineers, financial analysts, software and application developers, or data

analysts and scientists may equally face a low risk of displacement because their skills are expected to be precisely those needed to embrace new technologies. Existing workers would probably need retraining and reskilling to perform the job associated with new technologies. In fact, the demand for those occupations is expected to increase at a higher rate in the future. Wages are also expected to increase, as those occupations may face competition from other economic sectors who may be adopting similar technologies (IGF, 2021).

As Chapter 1 highlighted, women are currently significantly underrepresented in highly skilled and specialized occupations. In the future, as the demand for these occupations increase, women may be further marginalized in the mining workforce, unless deliberate measures are taken to equip them with the necessary skills, generally associated with qualification in STEM.

It is important to note that new technologies will also require new sets of skills that are not necessarily related to STEM education but associated with cognitive abilities. Examples of emerging skills needed include creativity, problem-solving and critical thinking skills, analytical thinking and innovation, technology use, monitoring and control, quality control and safety awareness, leadership and social influence, and management of personnel (WEF, 2021).

The Canadian country report (IGF, 2022c) highlighted that some of those emerging occupations, notably those associated with other non-STEM qualifications, also had a large occupational gap that is important in women's employment in mining compared to other sectors. Examples include financial management (9%) and human resources management (14%), both of which can be recruited in business schools. Furthermore, with the introduction of remote operational centres, more women could be directed to dispatch roles, whose occupational gap is 14% in Canada.

As previously mentioned, the gender pay gap is also higher in those occupations where men already dominate in terms of the highest- and better-paid positions. The recruitment of highly skilled individuals, and the retraining and reskilling of employees, if gender-blind, could exacerbate inequalities between men and women in those occupations and hence contribute to further widening the gender pay gap in the future.

As can be seen in Figure 23, the highest risks are expected to be faced by low- to mid-skilled and mid-to high-skilled workers. These include occupation categories such as clerical support workers, drivers and plant and machine operators, and trades workers (e.g., blasters, machinery mechanics and repairers, electrical equipment installers and repairers, metal workers). These occupation categories currently make up a large share of mining employees, and they often are characterized by routine tasks that have the highest potential of being displaced by machines.

The clerical support workers category is dominated by women uniformly across all countries studied for the purpose of this report. Data from Australia, Brazil, Mongolia, and South Africa all suggested a gender shift in the drivers and plant and machine operators' category where women are becoming increasingly represented. For example, the share of women employed as machine operators in Mongolia has jumped significantly, from about 6% of the female workforce in 2014 to 15% in 2020. However, the arrival of new technologies, such as automation and robotics, represents a high risk for these occupations and might threaten progress made so far. The baseline study from Australia even cautioned about this trend, highlighting that women's increased presence in these occupations might result from men shifting to other occupations that are in higher demand due to the arrival of new technologies.

Feature 3: Disruptive technologies and gendered impacts for future job location

These occupational changes will have significant implications for local communities, and in particular for women. As highlighted in Chapter 1, large-scale mining operational activities primarily take place in rural areas, where alternative economic opportunities and average levels of education are generally lower compared to urban areas where mining companies' headquarters are located.

As country reports and ILO data highlight, large-scale mining is a significant employer for mining communities, and the latter are employed largely in low- to mid-skilled occupations. ILO data show that the rate of employment of locals in the three countries where detailed data was available (Brazil, Mongolia, and South Africa) had been the highest in occupations working as machinery operators, elementary occupations workers, and craft and trade workers. As mentioned above, these types of occupations are most at risk from disruptive technologies. Even if new and better-paid jobs could be created, workers in those occupations may not be the best equipped to vie for the higher-skilled jobs.

Not only can access to education differ widely between urban and rural areas, but there is arguably, a significant digital divide, across geographical areas within countries. This divide is present in both access to basic digital infrastructure like the Internet and to Wi-Fi connectivity, but also in the skills needed to use digital tools (World Wide Web Foundation 2020). This gap is significantly wider for women and therefore raises a major concern for women in local communities, who are already disadvantaged in the labour market due in part to the existing digital gender divide. If there is no dedicated support to address this structural issue, women could find themselves disproportionately impacted by the introduction of new technologies.

Disparities in digital literacy for women are also stark across countries. In higher-income countries like Australia, the task of upskilling is made easier by the relatively high levels of digital skills among the active population: a 65.5% progress score, weighted average for 2019–20 (WEF, 2020). Similarly high scores are recorded by Canada, which is likely to provide more opportunities for women to transition to digitalized occupations. However, in lower-income countries, where the level of digital skills may be lower, women in local communities may encounter greater challenges getting trained and upskilled to perform the emerging tasks.

Loss of income during job transition may exacerbate poverty and inequality in local communities, particularly in countries with no adequate social protection policies, with significant consequences for the social fabric. As well, the advent of remote-controlled operations will put rural mining workers in direct competition with other nationals (also locals, by some definitions) and even with global workers, by removing the need for workers to commute to mine sites. This may exacerbate tensions between communities and mining companies but will unlock opportunities for other people in the country. Delocalization of staff will also affect the local economy, leading to closure of businesses dependent on mine workers and hence collateral job losses.

Loss of jobs in mining communities will impact women, who might face a decline in demand for direct and indirect mining jobs. Women will also be impacted by the loss of businesses that provide services to mine workers since these businesses are mostly run by women. The men in their families could also lose jobs, which could put further strain on community and household

dynamics and impact women's safety. Research has drawn a link between the downsizing of the mining sector and increased risks of domestic and gender-based violence in mining communities (Kotsadam et al., 2016).

Feature 4: Impacts of disruptive technologies vary across countries

Technological adoption varies across countries, determined, inter alia, by the levels of countries' development, their demographics (i.e., whether the population is relatively young or aging) with related impacts on wages, the skill set available, and the capacity of national education systems to provide talents needed. It will also depend on the skill sets and training infrastructure available in countries and the extent to which mining companies have invested in workers' training during their careers. The pace and breadth of technological adaptation will also vary for different genders, ethnic or Indigenous groups, rural or urban communities, and so on.

Further, investments in new technologies are driven by key economic factors, such as costs of labour; levels of investment required to improve efficiency and raise productivity; and the age of operation (i.e., greenfield or brownfield investments) that change from country to country.

The social contract and the degree of social acceptance of local communities are of crucial importance, in particular in lower-income countries or in regions with few alternative economic opportunities. In that regard, employment is a key expectation from local communities, and the skill sets available locally may determine the extent to which some technologies could be adopted (and likely the gendered impact on mine workers).

All these impacts will tend to be more significant in developing countries, where economic activities are less diversified and countries have a larger workforce in lower-skilled employment with low educational attainment levels compared to advanced economies (Usman & Landry, 2021). Data from Ghana, a developing country, is useful to show the potential gendered impact of the technological uptake across countries. The Ghana report suggests that the opportunities for women to work in technical areas in the large-scale mining sector may be hampered by the lack of secondary/vocational/technical level of education, which is attained by only 12.7% of females compared to 21.5% of males across the national population in Ghana. This is reflected in the low (15%) female proportion in the 2019 total hours of training received relative to males, showcasing the limited on-the-job training options accessible to women.

In Ghana, about 92% of the labour force in the large-scale mines within the Chamber of Mines membership was skilled in 2020, of which women accounted for only 10%. The disadvantages facing unskilled workers in the mines of the future will be felt by Indigenous[21] female employees, who made up 27% of the total female mining workforce directly employed in 2020. This further highlights the lower levels of female educational attainment, particularly at the technical and advanced levels of education.

Excluding the quarrying subsector and focusing on the 23 mines for which data was provided by the Minerals Commission, Ghanaian women's representation in large-scale mines and their contractors was 13.5% in 2017, which decreased to 8% (2,597) in 2019 before picking up slightly to 9% (2,737) in 2021. The even lower representation of local women in the mining

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21 Indigeneity in the Ghanaian context refers to local community members employed in the mines within their locality.

workforce in developing countries like Ghana, therefore, signals a critical challenge for local women in mining communities that may easily be intensified by the introduction of more sophisticated technologies, which will be reflected in requirements for advanced skills.

This example helps us to understand that the country- and context-specific adoption of new and disruptive technologies may indeed have different gendered outcomes in countries with different development and gender equality indices. In contexts where local populations (especially local women) lack skills, education, and opportunities, the increased use of sophisticated technologies might require certain skills that cannot be sourced locally. In such cases, even if we observe an increase in women's overall representation in the sector, this positive shift might not be equally mirrored within local communities.

TABLE 6. Examples of occupational changes resulting from disruptive technologies

Technologies	Types of occupations impacted	Reasons for change	Types of restructured or new occupations
Artificial intelligence and robotics			
Machine automation	• Earthmoving operators • Mobile plant operators • Lifting truck operators • Drillers • Mechanics and machine repairers	Restructured occupations: Tasks redesigned	• Remote control operators • Controllers • Robotics engineers • Electronic engineers • Data analysts
Automated vehicles	• Heavy truck drivers • Train conductors • Railway brake, signal, and switch operators • Mechanics and machine repairers	Occupation obsolescence: Task redundancy	• Remote control operators • Process automation professionals • Robotics engineers • Software and app developers
		New tasks entering mining and new organizational structures	• Software and app developers • System analysts • Robotics engineers
Uncrewed Aerial Vehicles (drones)	• Geologists • Mining engineers • Surveyors	Augmented occupations: Tasks enhanced/ modernized	• Remote control operators • Data analysts and scientists • Remote sensing scientists and technologists • Engineers and technicians, various fields (with augmented abilities)

Technologies	Types of occupations impacted	Reasons for change	Types of restructured or new occupations
IoT; connected devices; digital infrastructures			
Connected wearables	• Geologists • Mining engineers • Surveyors	Augmented occupations: Tasks enhanced/ modernized	• Remote control operators • Data analysts and scientists • Remote sensing scientists and technologists • Engineers and technicians, various fields (with augmented abilities)
Virtual/augmented reality Digital twins	• Engineers • Data analysts • Controllers	Augmented occupations: Tasks enhanced/ modernized New tasks entering mining and new organizational structures	• Remote control operators • Big data analysts • System administrators • Computer network professionals • ICT professionals
Cloud computing Big data analysis	• IT specialists • Data processing operators	Augmented occupations: Tasks enhanced/ modernized New tasks	• Software and App developers • Big data specialists • IoT specialists • Cyber security specialist

Technologies	Types of occupations impacted	Reasons for change	Types of restructured or new occupations
Digital transactions			
Blockchains	• Accountants • Procurement officers • Financial analysts	Augmented occupations: Tasks enhanced/ modernized	• Management and organization analysts • Big data specialists
Image, text, and voice recognition and interpretation	• Data entry clerks • Material recording and stock-keeping clerks • Word processors • Administrative secretaries	Occupation obsolescence	• Tasks to be subsumed into other occupations
Management, risk analysis, corporate affairs			
	N/A	Potential new occupation, not present in significant numbers in mining	• Training and development specialists • IT security analysis • Social science researchers • Risk management specialist

Source: Authors' analysis based on IGF, 2021.

Trend 2: Climate change and energy transition will impact mining jobs.

Climate change is a threat to economies, people, and life on Earth globally. Its effects are already noticeable, and they are expected to grow with more intense and frequent meteorological events. Since the 1800s, human activities have been the main drivers of climate change, primarily due to the growing consumption of fossil fuels like coal, oil, and gas. While transitions to environmentally and socially sustainable economies can become a strong driver of job creation, they will undoubtedly alter the functioning of many economic sectors.

To tackle climate change, governments, businesses, and civil society are increasingly making commitments to reduce their greenhouse gas (GHG) emissions and are adopting more sustainable consumption and production habits, namely by embracing the energy transition toward more renewable sources. In 2015, by adopting the Paris Agreement, 196 countries agreed to acknowledge global warming as a major threat and agreed to take action to limit it to 2% compared to the preindustrial era by the mid-century with a target of 1.5%. Combined with climate change generally, this commitment, widely shared by businesses worldwide, will have many implications for the mining industry. This report focuses on three issues:

- First, the transition to a low-carbon economy, notably engagements to step up the development of renewable energies and electric mobility to lower GHG emissions, will require significant amounts of minerals and metals that the mining industry is expected to supply.

- Secondly, the mining industry itself has committed to playing its role in decarbonizing its operational activities and supply chains. Levels of efforts are expected to increase as investors are particularly vigilant about the carbon footprint of companies in which they invest.

- Finally, as the effects of climate change are increasingly being felt and are disproportionately impacting some regions over others, the mining sector is working on ways to adapt to these new environmental conditions and mitigate their impacts.

Feature 1: Rising demand for minerals needed for the energy transition

The energy transition away from fossil resources toward renewables is driving demands for the mining industry to supply the world with minerals and metals at a pace never seen before. For example, an electric vehicle typically requires six times more metals than a conventional one. Similarly, since 2010, the average amount of minerals needed for every new unit of power generation capacity has increased by 50% as the share of renewables has risen (International Energy Agency, 2021).

Furthermore, this rise in overall demand for minerals and metals is accompanied by a shift in the metals needed. Some minerals are more "critical" than others, given their role in industries such as the manufacturing of renewable energy solutions, the fabrication of electric vehicles or the production of electronic components and consumables. The demand for these in particular is expected to rise exponentially, with repercussions for mining activities expected to follow suit. More mining activities, in turn, will undoubtedly affect demand for labour and as highlighted in the previous section, future mines are likely to be more technologically sophisticated.

The demand for "critical" minerals, such as copper, cobalt, lithium, nickel, manganese, and rare earth elements will also depend on technological development and will require policy support. In effect, from a geological perspective, the fact that ore grades are lower means that the overall quantity of ore needed to be discovered and mined will increase significantly, representing both a challenge and an opportunity for the large-scale mining industry. One way in which such a challenge could be met is by the reprocessing of old mine tailings. Indeed, mine tailings may still contain mineral grades that might become profitable under current economic and technological conditions. Additionally, they may contain minor occurrences of other minerals, some of which are now considered as critical and whose market price might create incentives for processing. These will create new perspectives, including for the labour market.

The above dynamics, triggered by the rising demand for critical minerals, will arguably result in more exploration activities, a phase of the mining life cycle in which women are sometimes found to be more engaged. These will have direct gendered consequences for mining occupations. For example, an increase in greenfield mining exploration projects will require significantly more scientists, such as geologists, geophysicists, data and remote sensing analysts, and so on, than what is currently needed. Reprocessing of mine tailings may require more scientists and engineers with chemical, biological, and environmental backgrounds.

Data from the 12 baseline country analyses indicated that women with scientific backgrounds in large-scale mining were proportionately more represented in fields such as environmental science, geology and geoscience, and data processing.

The rising demand for minerals needed for the energy transition and for the digitalization of technologies and the related scaling up of large-scale mining activities could very well be an opportunity to increase women's presence in mining work. However, there will be no automatic transition, as experience from technological adoption suggested above. Furthermore, the possibility that these new mines would be in remote and rural areas may pose access challenges for women.

Feature 2: Decarbonization of the mining industry

Given its large footprint, the mining industry has an important role to play in the limitation of its own footprint on the environment. Many of the largest mining companies in the world have set targets for their CO_2 emissions, including members of the ICMM that have collectively committed to a goal of net zero Scope 1 and 2 GHG emissions by 2050 or sooner (ICMM, 2021), with some companies, such as BHP and Vale, having even shorter-term goals with a 30% reduction target by 2030 (McKinsey, 2021). Ways for mining companies to decarbonize include divestment of heavy carbon-emitting operations such as coal mines or acting on the Scope 1 (mostly emissions from diesel mobile equipment) or 2 (convert heavy fuel power plants to renewable energy plants).

HIGHLIGHT 18: WHAT IS THE ESTIMATED CARBON FOOTPRINT OF MINING?

Studies estimate that the mining industry currently accounts for 4% to 7% of GHG emissions globally. Scope 1 emissions, attributed to emissions from direct mining operations, and Scope 2 CO_2 emissions, incurred through power consumption, amount to 1% of total emissions. If fugitive methane emissions from coal mining are included in the calculations, total CO_2 emissions are estimated at 3% to 6%. Given the important uses of mining inputs in industrial applications, the sector is estimated to indirectly contribute 28% of global emissions when the combustion of coal is included (McKinsey, 2021).

From a practical point of view, decarbonization of mining operations will be performed through specific technological improvements, such as electrification of hauling truck fleets, the switch to renewable energy sources, changes in mining processes to improve energy efficiency, and the switch from diesel to alternative energy sources, such as hydrogen. This transition has already started, for example, with Anglo American launching a hydrogen-powered truck at its Mogalakwena mine in South Africa in May 2022 ("South Africa Launches," 2022). Those changes will have a direct bearing on the types of machinery and equipment currently in use, suggesting that the personnel operating that machinery will need to switch to new equipment.

Out of the suite of different changes likely to be deployed to green mining operations, it is expected that new opportunities will emerge. One example is the operation and maintenance of renewable energy and storage solutions, which are not common in mining. These activities will require technical expertise that may not currently exist or is not necessarily associated with the mining industry. The need for such expertise is nonetheless expected to gain more prominence with the acceleration of decarbonization processes. This will call for a coordinated approach between governments and mining companies to develop strategies to anticipate the jobs, and therefore the skills, that will be needed to prepare the future mining labour force. To be successfully inclusive, these strategies will need to mindful of the gender gaps and challenges mines currently face with their labour force and address them accordingly.

Rising demand for minerals and metals needed for the transition will arguably bring new opportunities for women. In South Africa, the energy transition will drive up demand for chrome, manganese, and iron ore, with implications for the demand for labour. The South Africa report already highlighted that the highest percentage of women employed per commodity was found in chrome and iron ore. Diamond, coal, and manganese came after, each with the same percentage average. In Mongolia, women were primarily employed in metal ores, some of which will be in high demand in the future, followed by industrial mining, such as stone and brown coal, and the least employed in other mining and quarrying activities.

The transition away from fossil fuels will have significant implications for the types of minerals likely to be mined. Although outside the scope of this report, one may expect that coal mining would gradually diminish over time. Data from Australia, Mongolia, and South Africa suggest that women are less represented in coal mining than in the mining of ores. In Australia, coal mining had the lowest share of women's employment, which could be due to the effects of early banning of women's employment in underground mines. The Canada report also showed that coal had the lowest share of women in employment, with the caveat that the data sample is small and demonstrates the difficulty obtaining women's employment by mining

subsectors. Those present will be affected, and there is a need to find solutions to ensure a just transition, to avoid negative consequences on livelihoods and hence exacerbate poverty levels. However, while there aren't enough data available to suggest this is a trend, it is worth noting, especially considering the future of mining and upcoming coal phase down.

Feature 3: Adaptation to climate change

In addition to the above two features, the mining industry will need to take proactive actions to adapt existing processes to avoid the unintended consequences of climate change, such as extreme weather conditions. Over the past decades, the overall effects of global warming have been felt across countries, notably through systemic changes observed in natural ecosystems, such as the drying up of water streams, advancing desertification, or loss of permafrost. In addition, there are increasingly frequent and intense extreme events, such as droughts, heavy rains, or hurricanes, that have important implications on infrastructures.

In general, those recurrent events are expected to affect women and men in different ways. For instance, women face higher risks of poverty as a consequence of climate change due to their reliance on natural resources for their livelihoods, and due to their often-limited capacity to respond to climate events. Different groups in a given community also have different use and needs of natural resources and knowledge and roles regarding its management (United Nations Framework Convention on Climate Change, 2022).

Managing the interface between mining activities and communities is particularly important, as competition for scarce resources, like water and land, increases. In many cases, mining operations are very water intensive, and access to land and water may lead to rising conflicts with other user groups, such as pastoralists, farmers, local industries, and local households. Many companies are investing in water-saving technologies and efficient recycling to improve their own processes and avoid potential conflicts with communities.

Similarly, to adopt renewable energy solutions, those new processes will probably require expertise to manage and maintain new machinery. Some existing occupations, such as hydrologists and engineers, will be expected to work on those new processes, while new opportunities will arise for new tasks related to the relevant technologies embedded in the new machinery. Again, these will have gendered implications relating to the types of skills that machinery and new process operations will require.

Extreme events may have an impact on the sustainability of mining projects. Severe weather conditions may affect the integrity of mining installations, the stability of slopes of open pits, and critically the tailing's storage facilities, whose breaches could lead to potentially disastrous consequences for entire communities.

HIGHLIGHT 19: EXTREME WEATHER CONDITIONS IN AUSTRALIA COST MINES MILLIONS.

The weather in Australia can be highly variable. Often considered a "dry" continent, the country is subject to significant variability, with some periods experiencing heavy rainfalls, while others are dryer (Bureau of Meteorology of Australia, 2012). Regions such as Queensland, New South Wales, and Western Australia have been severely affected by extreme weather conditions, with very significant implications for mining operations and minerals production. Losses related to the 2010–11 floods in Queensland were estimated at AUD 30 billion, and losses to the mining industry alone were roughly AUD 2.5 billion (Easdown, 2011).

To avoid accidents and catastrophes, mining companies are increasingly required to incorporate planning and management of extreme weather events and consider impacts from climate change into mine design, project development and construction, mining and processing operations, and post-mining phases, such as closure and rehabilitation. This will necessarily require a whole set of competencies and expertise along the entire life cycle of the mine, with gendered implications for the mining workforce, including for the safety of workers. To safely manage mining projects, mining companies will have to hire specialists, including with competencies in climatology and meteorology.

The need to offset carbon emissions, to mitigate the impacts of climate change, and the necessary rehabilitation of mining sites all highlight the need for expertise in environment-related fields to help address the negative implications related to climate disasters and restore the natural environment disrupted by mining activities.

Several baseline studies suggest that women with STEM degrees tend to be more concentrated in fields such as environmental sciences. More demand for expertise in those fields could open opportunities to increase the presence of women in those occupations. Further indication of women's increased involvement in closure, for example, suggests that mining jobs in the future could be conducive to the increased presence of women.

Additionally, mining operations are increasingly being assessed on their environmental footprint and on their relationships with communities. This calls for investments in human resources dedicated to sustained community engagement, notably to manage and avoid possible conflicts over scarce resources or land management. Those occupations will require an understanding of gender dynamics at the community level if women are to be fully included in consultations and decision making, both to gather and disseminate local knowledge in natural resource management but also to acknowledge the specific needs and capacities of different groups with regard to land and resource use.

Table 7 offers examples of the expected impact of climate change and decarbonization on occupations and required skills.

TABLE 7. Potential labour impacts of rising demand in minerals, decarbonization, and climate change in the labour market

Feature	Causes of change	Impact on industry	Impact on labour market
Rising demand for minerals	New/greenfield exploration	• New exploration techniques, additional geophysics. • Possibly new frontier of exploration (Arctic zones, deep seam mining, remote location exploration).	• Geologists, geophysicists, well drillers, borers and related workers, data analysts, and scientists. • Remote sensing scientists. • Augmented tasks due to artificial intelligence and use of connected devices.
	New mining projects onstream	• More mines will be needed, implying more permitting processes, pit constructions, plants to be delivered, and testing to be done. • Additional infrastructure to bring ore to consumers.	• Rising demand for mining labour. • Construction workers, occupations required in standard mining operations. • Use of new technologies may require different types of expertise and skills.
	Extension of geographic footprint	• Potential conflicts with communities.	• Human resources capabilities with dedicated staff to consult and engage communities and manage conflicts.
	Tailings reprocessing (including search for critical minerals)	• Advanced metallurgy needed and possibly new equipment to process waste. • Advanced exploration and metallurgical processes to separate elements from the ore.	• Will require expertise in waste management, safety, tailings management, water and other chemical analysis etc. • Will also require geologists and geophysicists, and related workers, metallurgists and related professionals. • Experts in environmental risks. • Climatologists and meteorologists to anticipate extreme weather conditions.

Feature	Causes of change	Impact on industry	Impact on labour market
Decarbonization	Divestment of high-GHG emitting operations	• Change of ownership from ESG responsible companies toward less-responsible ones.	• Workers at mine sites may be affected by new ownership and restructuring of activities.
	Electrification of mining fleet	• Electrification of mine operation, need for batteries and electricians.	• Motor vehicle mechanics and repairers. • New equipment, such as batteries and charger points will require maintenance and repairs technicians. • Electric vehicles will require technicians to manage, monitor, and repair new equipment.
	Switch from heavy fuel to renewable energy power generation	• Installation and management of renewable energy (solar panels, wind turbines).	• Power production plant operators, mechanical engineering technicians. • New expertise to manage, maintain, and repair renewables.
	Rehabilitation of mining sites	• Reforestation, regenerative agriculture, revegetation.	• Specialists in environmentally related fields • Environmental protection professionals. Environmental engineers; biologists; botanists; zoologists and related professionals; farming, forestry, and fisheries advisers; landscape architects. • Forestry technicians. • Inspectors. • Land-planning experts. • Nature and conservation scientists.
Adaptation to climate change	Water management and recycling	• Water-saving technologies, waterless mining, closed-loop mining, water recycling processes, additional treatments.	• Water treatment plant operators. • Chemists, biologists, water inspectors. • Hydrologists. • Climate specialists.
	Management of tailings storage facilities	• Geotechnical work, monitoring of actual and closed tailings storage facilities.	• Weather specialists, civil engineers, geotechnical engineers, structural engineers.

Source: Authors' analysis.

Concluding Remarks

Will the mining workforce reach improved gender parity through the transformation of what is being mined, where it is mined, and how it is mined? The shift from coal to cleaner energy or the introduction of more sophisticated technologies may indicate more opportunities for women, but this optimistic outlook is context specific and tied to many other factors.

Overall, by leaving behind the very masculinized legacy of coal mining and focusing on minerals that promise a better future, the mining sector may attract younger talent, including younger women. However, this depends on many variables, above all, the working culture and conditions that mining companies either retain or transform.

Finally, the attainment of greater gender parity in the mining workforce of resource-rich countries will require a thorough strategy to retool and upgrade the competencies of the existing labour force, with measures to retrain, reskill and upskill workers. Concurrently, programs to develop new skills in particular for women in local communities will be required, as the future of mining will provide new opportunities in fields not traditionally associated with mining.

Phase 2 of the WMF project will explore the skills needed to prepare local communities—in particular women, youth, and other less-represented groups in these communities—for the transition that has already begun. If the large-scale mining sector is to contribute to the attainment of SDGs 5 and 8 (on gender equality and decent work), evidence-based, data-driven, and context-specific gender equality policies will have to be prioritized by both governments and the mining industry and promoted by workers' organizations and WiM organizations around the world. The following chapter explains the gaps, challenges, and room for improvement to better collect, analyze, and monitor the gender-disaggregated data needed for such policies.

3.0 Data Gaps and Challenges

The Importance of Data Collection for Public and Corporate Policy Design

Data is essential for the functioning of governments and businesses alike. However, for information to be effective, it needs to be accurate, timely, and credible to allow for the design of evidence-based policies and, in the case of governments, contribute to a sound development process from which policy-makers can learn from their mistakes and be held accountable (World Bank, 2000). As Chapter 2 explains in detail, required mining sector skills are changing significantly under the trends driven by climate change, disruptive technologies, and rising demand to mine more responsibly and equitably.

These fast-changing dynamics have significant implications for the work of the future. Occupations in large-scale mining will be different—some jobs will be lost, existing jobs will be performed in new ways, and new jobs currently not considered as mining jobs will be required. There is a need to understand the opportunities and challenges to break the gender bias in the mining workforce and developing public and corporate policies to advance gender equality in the mining sector. This effort will largely depend on the availability, quality and reliability of data about types of occupations, different and new skill set that be needed to perform mining jobs, and changes in the working environment and conditions that will have to occur.

In practice, however, the availability of good data is patchy at best, especially sex-disaggregated labour statistics by sector. While many countries can produce reliable labour statistics, it is not uncommon to come upon incomplete or non-existent data sets, as also explained in Chapters 1 and 2 of this report. When it comes to public data, this usually boils down to the need for greater investments in statistical agencies, including everything from staffing to the availability of modern technology. A strong statistical agency must be able to "provide information relevant to current and future policy issues, to establish credibility for itself and its data, and to be respected and trusted by those whose information it obtains" (Straf, 2001).

As to the data that is collected, when it is tabulated separately for women and men, policy-makers have the possibility of more accurately assessing differences in the situations of each sex on several social and economic dimensions. With data disaggregated by sex, it

is possible to build gender statistics that reflect gender roles, relations and inequalities in society (European Institute for Gender Equality, 2022). When gender data is not available, it opens the door for general and generic assumptions (as well as shortcuts), preventing the accurate assessments of situations. Furthermore, the ability to measure, pre-empt, and respond to challenges is hindered, which undermines the design of effective responses to impacts. If the large-scale mining sector is to contribute to the achievement of Sustainable Development Goal 5 on gender equality and Sustainable Development Goal 8 on decent work, it is necessary to address these data and analytical gaps.

Data Challenges

The research carried out for this project revealed many challenges regarding data and their reliability. As a starting point, data made available to the ILO by its member states were used. It must be underscored that employment data is collected either through labour force surveys or household surveys. Responses from these national surveys are not necessarily disaggregated by sex. Some countries do not collect them regularly and use their own national classifications, which may not be standardized with international classifications. As a result, national employment statistics submitted to the ILO do not always have the same level of detail. This was a major constraint, as we did not have the same level of data analysis for all countries surveyed for this project.

As shown in Chapter 1, not all countries have sex-disaggregated statistical information. In some countries, quantitative data describing the mining sector is highly fragmented. They are sometimes collected by several agencies, which makes it challenging to gather a comparable and comprehensive—not to mention gendered—snapshot of the workforce. When quantitative data was not available, or insufficiently reliable, the analysis was complemented by corporate data reported by mining companies to their industry associations or councils, or obtained by request (IGF, 2022e).

Furthermore, not all collected data are made publicly available. National laws on data privacy, as is the case in Peru (IGF, 2022g), for example, make it challenging to access data and, consequently, to assess and understand the gender specificities of the industry in some countries. And, although data collected directly by mining companies at their sites could provide a more granular understanding of the industry, they are rarely publicly available.

Sex-disaggregated corporate data collected by the mining sector are sometimes available but not necessarily filtered and analyzed for policy-making. One particular example is Mongolia. Upon request for this study, some companies filtered data—such as men and women employees receiving training or skills levels segregated by sex—from their human resource registration systems. If they were better reported, those data could be arguably used for policy-making and implementation as well as for assessing the impacts of policies and programs (IGF, 2022f).

Another challenge encountered across many countries analyzed in this report is the lack of qualitative and gender-responsive analysis. Part of this challenge relates to the lack of data standardization that converts data to a common format that enables users to process and analyze it. This is critical to complement and help interpret the statistical data collected by human resource registration systems. The absence of good qualitative analysis therefore sometimes results in a disconnect (and even inconsistencies) in companies' sustainability reporting on their achievements and gender parity (IGF, 2022c). This makes it difficult to

uncover the gendered dimension of recruitment and retention practices. In addition to this, publicly available data on workplace discrimination and harassment is largely invisible, as mining companies do not report these incidents in sustainability reports (IGF, 2022c), albeit with some exceptions noted in this report.

Another limitation observed in data sets concerns the definitions of sex and gender. In all countries, with the exception of Canada, the data collected and represented in national statistics are disaggregated by sex and are not sensitive to measuring trans or non-binary persons, making it impossible to develop fully inclusive public and corporate policies. While the Canadian government has a target parity of 50% for gender representation and 30% for equity-seeking groups that include Indigenous Peoples, visible minorities, people with disabilities, and members of the 2SLGBTQ+[22] community, the publicly available data at the time of writing this report did not include such segregation in the analysis (IGF, 2022c).

Overall, these findings confirm that despite best efforts, it is important to recognize that there are flaws in the statistical system and that building countries' capacities to produce and use statistics is essential to contribute to the identification of needs of different groups and the design of adequate policies in the mining sector.

Challenges regarding the collection and use of data may differ, but based on the findings of the WMF project and tapping into ILO's experience, it is possible to identify common areas of concern:

1. Staffing

To use data adequately and responsibly, there is a need to enhance the capacity of professionals responsible for collecting and analyzing data in data-related skills and competencies. It is important that both governments and mining companies understand how to use data for the development of policies, how to foster the technical skills to manage and analyze data, and how to hone communication skills capable of presenting findings to a wide range of audiences.

Research carried out by the Government of Australia showed that data skills are essential to "support evidence-based, informed decision making, whether in policy development, programme management or service delivery" (Government of Australia, 2016). The country has committed to promoting data use and data capabilities to encourage public sector efficiency. It expects that it will need more data analysts, data policy and law experts, data scientists, data infrastructure engineers and data architects. Concurrently, the Australia country report showcases the most granular and comparable data that is disaggregated by sex and also analyzed for multiple indicators (i.e., age–gender–occupations; pay gap–gender–occupations etc.).

Technical skills and capabilities should be sharpened to allow for responsible data collection, access and sharing. This also includes "promoting data literacy among the public and increasing citizen's capacity to understand relevant data governance issues and exert their rights" (OECD, 2021).

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22 2SLGBTQ+ is an acronym that stands for Two-Spirit, Lesbian, Gay, Bisexual, Transgender, Queer or Questioning and additional sexual orientations and gender identities.

2. Data Accessibility

While there may be data available, outdated technology and lack of coordination between statistical agencies contribute to making the extraction of information (and its use) difficult. In several baseline studies, the data reported were only as good as that collected and reported by mining companies to national statistical bureaus. Data were also limited by the frequency of census and labour force surveys, and it informed the choice of study periods for each country report. Another difficulty in the collection and analysis of data was the presence of regional variations in the same country. Legislation regarding mining can be regionally specific as opposed to national, making countrywide data collection, analysis, and identification of national trends more complex.

Private companies have been able to harness incredible amounts of information through blogs, social media, sensor networks, image data, and other forms of data. While there is no universally agreed definition of "big data," it is a term "used to describe the process of applying serious computing power—the latest in machine learning and artificial intelligence—to seriously massive and often highly complex sets of information" (IBM, 2013).

Governments are now accessing big data and incorporating it into official statistics to make them "more accurate, affordable to gather, and more attentive to geographically remote or otherwise marginalised communities" (Johns et al., 2018). In an assessment conducted by the UN Statistical Commission, of 93 national statistical offices, most countries were interested in using big data for "faster, more timely statistics, reducing response burden, and creating new products and services" (National Academies of Sciences, Engineering, and Medicine, 2017).

There are, however, issues relating to the use of big data in the context of public policy. Private data cannot be audited, methods used for collection may not be straightforward, official statisticians are left dependent on privately owned infrastructure, and the data gathered may not be fit for state purposes. Beyond use by governments, big data has been one of the mining industry's tools to support efforts to reduce the cost of operations and improve efficiency. Not only can big data help refine business operations, but it can also help reduce downtime and boost efficiency of equipment, support the management of people, give insights into future operations, and minimize risks (Mining, 2020).

3. Data Quality

Data collected can often be inaccurate, incomplete, or fragmented, which compromises the accuracy of the information obtained. This problematizes not only the reliability of the data but also any decisions that are made based on it. While this is a common challenge, it takes on greater importance when considering gender-disaggregated data.

To generate high-quality statistics and contribute positively to gender-based analyses, gender bias must be eliminated from survey data, and the methods used for its collection and the statistics produced. Gender bias can be imported through statistical error "relating to how adequately a survey sample corresponds to the population of interest, and how adequately statistical concepts correspond to the subjects, objects and phenomena they represent" (ILO, 2022).

Conversely, gender bias can occur due to blind spots or omissions. This is particularly relevant in the field of labour statistics, where stereotypes of what roles are commonly assigned to

each sex can bias what gets measured, counted, and made visible in statistics. In the mining sector, for example, where women workers are not as common as men, statistics can be skewed by the small sample size available, even if data were collected correctly. This was the case when accessing data from Argentina for this paper. The information obtained appeared statistically insignificant given the sample size of women reported, perhaps requiring additional efforts to generate reliable data that could adequately illustrate the situation of women in the industry.

4. Data Sharing

New technologies have allowed us to generate more data than ever before. However, to get the maximum value out of the data gathered, they need to be shared between agencies and countries. To that end, there are technical aspects to be reckoned with, as well as issues of data privacy and security.

On the technical side, systems need to be interoperable, meaning that a data-sharing ecosystem needs to be put in place whereby the various IT systems can exchange and effectively use the existing data. In Europe, for example, where governments are highly digital, the easy flow of data needs to be guaranteed to provide efficient electronic services. This means that information systems must be able to communicate and make sense of the data.

Regarding data privacy, governments and businesses must be transparent about how data is collected and shared. They must establish trust to foster a culture of effective and responsible data access, sharing, and use.

The ability to access data publicly is essential to analyzing the sector and identifying trends and needs. This became clear during research for this paper, when data made available by the Australian government made it possible to cross-reference information, which led to meaningful gender analyses. The national data protection requirements in Peru, on the other hand, made it impossible to reach anonymized and aggregated employment data, which had a toll on the granularity of the analysis that could be made for policy purposes.

In late 2021, the OECD adopted a Recommendation on Enhancing Access to and Sharing of Data (2021) that established a "set of principles and policy guidance on how governments can maximize the cross-sectoral benefits of all types of data—personal, non-personal, open, proprietary, public and private—while protecting the rights of individuals and organizations." While it is expected that the sharing of data will enable collaboration and the innovative reuse of data for growth and well-being, the impacts and feasibility of this recommendation on OECD and non-OECD member countries are yet to be observed.

Concluding Remarks

The collection and application of accurate, reliable, and gender-disaggregated data are invaluable to both governments and businesses looking to promote change and create better opportunities for women in the mining industry. Access to the right data can support the definition of the policies needed to create a working environment that sees and fosters women and can help the large-scale mining sector's quest to support the development of people, communities and the planet.

4.0 Key Findings and Recommendations

Key Findings

#1: Women's participation in the mining workforce is generally trending upward but at a slow pace. However, deep structural inequalities remain.

Findings from the data gathered in this study show that women's representation in the mining industry is slowly trending upward but persistent and structural inequalities have remained relatively unchanged over the last decade. Understanding the trends and nuances specific to countries and regions regarding women's employment in the sector is pivotally important to curate and implement evidence-based strategies to overcome the entrenched barriers impeding women from benefiting equally from employment in the sector.

One striking finding from this study is women's overall higher educational level across most mining occupations compared to men. This was observed across countries, irrespective of their levels of development. However, differences were observed when fields of education were considered. Women's lower representation in STEM-related occupations in mining was noted across all countries in this study—a trend that was generally observed at the national level as well.

An important issue became apparent in countries such as Canada, Australia, Sweden, and South Africa, where women have relatively high STEM-related education attainment. However, it was noticed that women did not prefer to work in the mining sector despite the higher wages the sector offered.

Furthermore, the findings allowed a better understanding of nuances between education (i.e., number of school years attended) and skills (i.e., competencies developed based on the field of studies taken). Even though women join the mining sector with a higher level of education, there is a mismatch in terms of competencies needed for specific occupations. This is particularly relevant for occupations that require technical and vocational training, and where a large number of job opportunities are offered on mine sites.

While women are more represented among those who are employed on a part-time basis, being employed in part-time jobs does not mean that women work less in general. On the

contrary, women often perform more hours of unpaid work, such as childcare or housework, which leaves less time for paid work.

Furthermore, considering that female mining workers tend to leave work at a certain age, we can infer that this portion of women is likely to face higher financial risks when they get older. In fact, this is not only a consequence of a lack of formal remuneration or disparity in salaries but is also one caused by early retirement or by interrupted career paths. Leaving the labour market early or having breaks in one's career imply an erosion of labour rights, such as lower contribution to pension schemes and hence less social protection and low level of retirement benefits. With less money to save and invest, these gaps accumulate, and women are consequently at a higher risk of poverty, rising inequality, and social exclusion at an older age. More adaptable working conditions and family-related leave would help balance private and professional interests and avoid having to choose between family and career.

Finally, the data highlighted in this report globally confirmed that there is the leaky pipeline in the large-scale mining sector, meaning that women leave the mining sector at an earlier age compared to men. Results across countries are fairly consistent, allowing us to underscore that there is a real concern regarding the retention rate of women in the large-scale mining industry.

#2: Understanding the structural barriers impeding gender equality in the mining sector is fundamental for policy-making.

The data clearly highlight that the current underrepresentation of women in the sector is not necessarily a supply issue. It is better explained by specific and structural barriers that are particular to the large-scale mining sector. The qualitative research carried out in South Africa, Mongolia, and Brazil for this project provides important evidence to understand the root causes of the challenges faced by women. These findings are important to help policy-makers and corporate executives develop policies and programs to overcome the gendered challenges in the mine of the future. Key issues that were brought forward by the research include:

- The working conditions that make it harder for women to establish work–life balance due to gender roles and gendered division of labour (i.e., lack of sound parental leave policies and childcare support, remote working stations, inflexible working hours).

- Masculine corporate cultures that tolerate high levels of toxic work environment factors such as racism, sexual harassment, and gender-based violence. The reasons for this situation can be traced to the hypermasculinity of the mining culture and how it allows these practices to be accepted—and even strengthened—due to male solidarity and organizational tolerance.

- Working conditions that do not prioritize the health and safety of women, including lack of fitting PPE, unadapted, men-only washing/toilet facilities and changing rooms, or lack of protective measures for pregnant and nursing women.

- Fewer opportunities for careers, including gender pay gaps that tend to be wider for higher-skilled women, underemployment of women, lack of career path development, less opportunity for sponsorship and mentorship, overrepresentation in administrative jobs, less opportunity for job shadowing/acting roles in management positions, and so on.

Despite the persistence of these challenges, the gradual adoption of corporate and public policies and programs targeting skills development and changing the work culture has started to result in some positive shifts. Recent years have witnessed encouraging trends, such as increased number of local women working in technical occupations, such as machine operators, or more women employed in emerging jobs like environmental engineers, social workers, and conservation specialists. In addition, Women in Mining organizations that are largely run by women volunteers, many of whom are also working full time in the mining industry, offer important services, including scholarships, recognition awards, networking events, conferences, education and training, and community outreach—all very pivotal to overcoming the structural challenges.

#3: Global trends affecting the large-scale mining sector require gender-responsive policies and programs to upskill, reskill, and train the mining workforce with a specific focus on women.

While the jobs of the future will require skills to use new technologies and will enable the mining industry to respond to challenges related to climate change, the scope and speed at which these transitions occur are expected to vary significantly depending on the context. To ensure the transitions facing the mining industry result in a just and equitable outcome for local populations, skills policies and interventions will have to be coupled with other active labour market policies as well as with social protection systems.

In the case of new technologies, there will necessarily be some redundancies as a result of the adoption of automated technologies. Chapter 2 highlighted occupations that are most at risk of redundancy or restructuring, some of which are performed mostly by women. This would require, where possible, managing transitions to other mining occupations. It could also require finding decent alternative livelihoods if these occupations disappear from the mining sector altogether. In other cases, there may be a gradual decline in demand for some occupations. This will require dedicated and gendered training programs to reskill, retool, or upskill workers so they can manipulate new or higher-tech equipment.

When new jobs emerge (in particular as mining companies adapt to or mitigate impacts of climate change), there will be a need to seek out new talents and competencies, including from sectors other than mining. In all these cases, regular on-the-job training will be needed, as technological changes are a recurrent feature to which the mining industry will have to continuously adapt itself.

Nevertheless, a proactive approach, engaging governments, mining companies, and workers with each other, is needed to address existing skills and educational gaps and identify new skills, to then, prepare the future workforce (and specifically women in the mining workforce or women who can be a part of the mining workforce) for changing and emerging jobs in mining and other economic sectors. In fact, women's historical and current disproportionate lack of representation in qualifications in engineering and related technologies, IT, and natural and physical sciences and STEM-qualified occupations calls for immediate actions to mitigate the challenges of participation.

#4: The depth of the gendered analysis of the mining workforce is closely tied to the quality, reliability, and accessibility of data, which varies across countries.

As highlighted in Chapter 3, robust analysis is only possible when robust data is available. This entails the data being accurate, reliable, accessible, detailed, and (preferably) comparable. One finding of the project was the inconsistency of these features across countries. Unless addressed at all levels, that is, by governments, mining companies, and international organizations providing globally comparable data, the continued lack of a consistent and detailed analysis of baseline data regarding gender equality in large-scale mining employment will persist and continue to prevent meaningful policy design, implementation, or reforms in response to the potential changes in future employment.

Another challenge was the inclusiveness and intersectionality of data. It was not possible to access gender-disaggregated data in any of the countries, as the data is uniformly collected and stored using binary sex categories, which makes it impossible to develop and promote evidence-based policies that consider non-binary or trans persons. Similarly, in many countries, data related to specific characteristics such as Indigeneity, ethnicity, socio-economic status, and so on are not collected, and data related to age, education, and occupations are not necessarily comparable against each other, which hampers the depth of analysis overall.

Policy Recommendations for Challenges and Opportunities

These policy recommendations are synthesized from the country-specific data and analysis performed as part of the WMF project. They are aimed at governments, but also relevant for companies, and aim to help harness the potential of women in the large-scale mining sector, at present and in the future.

TABLE 8. Policy recommendations for challenges and opportunities

Challenge	Policy recommendation
Challenge: Workplace culture and practices are not conducive to the employment and retention of women.	
Workplace discrimination, harassment, and violence primarily impact women in mining. Women's psychological safety issues are underreported and frequently unresolved.	• Governments should have a gender strategy for mining and an action plan (for the implementation of said strategy). The focus of these plans should include provisions for skills creation, employment, and retention. • Governments should introduce policies and legislation that incorporate and address workplace discrimination, violence, and harassment incident management in occupational health and safety legislation or as stand-alone policies, thereby improving access to justice for women in mining and increasing the transparency of psychological safety incidents. • Governments that still abide by the Underground work (Women) Convention No. 45 of the ILO that forbids women to work underground are recommended to denounce the convention and take appropriate measures to repeal the legislation and consider ratification of the ILO Safety and Health in mines Convention (No. 176) and other ILO conventions. Governments could also consider ratifying the Violence and Harassment Convention (No. 190). • Governments should promote the employment of women public officers in key positions related to mining, and encourage gender-equal participation and representation in their delegations at events and platforms. • Companies should adopt workplace anti-discrimination and anti-harassment policies and training to allow psychological safety incidents to be managed within occupational health and safety programs and systems, and grievance mechanisms, thereby increasing transparency and trust in reporting systems. • In this context, the relationship between related companies and contractors requires special consideration. Companies should require that their contractors also establish strict anti-discrimination and anti-harassment policies and propose actions for the implementation of these policies. • Companies should ensure the security aspects and human rights of their workers, including providing training to all staff on anti-harassment, providing counselling and other help to the survivors of sexual and gender-based violence, and ensuring that the grievance mechanisms are designed and managed to capture sexual and gender-based violence reporting in a survivor-centric way.[23]

23 Please refer to the Good Practice note by the World Bank to learn more about survivor-centric grievance mechanisms.

Challenge	Policy recommendation
Gender-blind workplace policies make it harder for women and men to establish work–life balance due to gender roles and gender division of labour.	• Governments should monitor the adherence to the legal minimum standards on parental policies set at the national level. Enforcement measures to address non-compliance should be in place and implemented. • Governments should incentivize the mining sector to implement international best practices as exemplified by the International Finance Corporation toolkit Unlocking Opportunities for women and Businesses. • Companies should design and implement corporate policies to overcome institutionalized socio-cultural conceptions of gender difference. • Companies need to conduct exit interviews to measure the impact of existing policies and improve them accordingly. • Companies should have parental leave policies that are supportive of women and inclusive of men. Ideally, such policies should incentivize men to use paternity leave on an equal basis and should be inclusive of LGBTQIA+ parents, adaptation leave, and bereavement leave. • Companies should implement corporate policies that ensure that parental leave does not impact an employee's career advancement in the company, for example, ensuring that promotions are not based on metrics that put employees on parental leave at a disadvantage. • During pregnancy, it is pertinent that company policies ensure the safety of pregnant women and offer a safe and conducive return-to-work plan (i.e., jobs that are not carried out in the mining fields, availability and accessibility of breastfeeding rooms and childcare near the work centres, and/or the assignment of bonuses or incentives for contracting childcare services).

Challenge	Policy recommendation
The gender pay gap reduces the earning power of women in mining, and, when combined with limited career prospects, women are discouraged from working or staying retaining in the sector.	• Governments should introduce policies to proactively promote pay equity reviews and reporting of mining companies. These policies should be regularly monitored and reviewed. • Companies should adopt annual pay equity reviews that identify and address gendered pay gaps. • Companies should adopt policies that target unbiased treatment of women with respect to skills development and career development planning. • Companies should publish their performance in their sustainability reports with breakdown of age, ethnicity, Indigeneity, educational attainment, occupation, pay gaps (including gender breakdown of new hires, promotions, senior leadership, boards, board committees etc.) and use ILO or appropriate international category standards for comparability. • Companies should clearly communicate the salary scale for the proposed position to encourage women to negotiate their salary. This helps the applicant know what they can reasonably expect and negotiate.
Women's health and safety are not prioritized.	• Governments should introduce minimum legal standards and monitor their implementation for the industry to ensure fit-for-purpose PPE, safe and separate sanitation facilities, and gender-appropriate health services for women workers. Governments should require the private sector to translate the minimum legal standards into corporate policies. • Companies should ensure that women workers have fit-for-purpose PPE and have access to safe and separate sanitation facilities and gender-appropriate health services. Companies are advised to ensure that all employees are fitted with appropriate PPE based on their gender and pregnancy status, mobility and ability status, or any other specific cultural or religious needs. Ensure facilities and toilets take into account the safety of women, and accommodate the sexual and gender diversity realities and needs of mine workers. Companies should consult their employees in conversations to assess their needs. Companies are advised to do workplace audits a minimum of every 3 to 5 years, ideally every 2 years to ensure that workplaces are inclusive.

Challenge	Policy recommendation
Challenge: Despite their higher educational attainment, women in mining tend to lack certain skills and are less represented in some educational fields that are important for better career prospects and the transition of jobs.	
At the national level, women and girls are less inclined to pursue STEM-based education in areas of critical important for the mine of the future.	• Governments, in consultation with employers' and workers' organizations, should design a national strategy to increase women's participation in STEM-based education beginning from early childhood education with attention paid to gender stereotyping from an early age. • In this framework, governments, industries (including the mining industry), and workers should work together to identify areas of expertise likely to be in demand in the short and medium term, with respect to STEM-related skills. • Based on the gap analysis and skills anticipation, governments, industrial sectors (including mining), and workers' organizations should design tailored skills development programs that include specific targets to increase the enrolment of women in STEM-related fields. • This should be accompanied by awareness raising campaigns (conducted by government and industrial actors) in schools, colleges, and universities about potential employment, apprenticeship, training, and scholarship, including financial support and mentoring opportunities for girls. • There should be targeted strategies and programs, initiated by governments and mining companies or through partnerships, aimed at women rural mining communities. • Challenges pertaining to women from historically disadvantaged groups such as Indigenous women or women from minority ethnic groups are often overlooked in government and corporate policies and strategies. There needs to be tailored education, technical training, and mentorship programs that take a long-term perspective, as well as placement schemes, to connect them with the different occupations in the mining sector. This work should be done in collaboration with women's groups, Indigenous groups, and other relevant stakeholders to ensure that they are part of decisions made about them.

Challenge	Policy recommendation
Women, and especially local women in developing countries, are less represented in occupations that require technical and vocational training and where a large number of job opportunities are offered on mine sites.	• Governments and companies, in consultation with workers and their organizations, should invest in the capacity of women in large-scale mining, in particular from communities, with a focus on mining technologies, such as artificial intelligence and digitalization, and energy transition solutions. Skills development in areas like process and resource engineering, IT and programming, data analytics, system designs, as well as technical, machine operation, and trades skills should be targeted for women in mining. • Similarly, training programs in the skills necessary to adapt to and mitigate the impacts of climate change, such as in areas like environmental engineering, geotechnical engineering, and land conservation and restoration, should be targeted for women. • Companies should prioritize and incentivize their women employees to benefit equally from on-the-job training opportunities and support their technologically-driven upskilling. • Mining companies, local governments, and other local industries should collaborate with workers' organizations and civil society organizations to provide digital skills to workers in mining communities. Women in particular should be targeted to address the gendered digital divide. • Mining companies, local industries and local governments should provide and/ or share the infrastructure needed to support science, technology, and innovation. This includes electronic and engineering equipment, energy supply, reliable Internet services, laboratory facilities, and good transportation and communication systems. They are important to enable the workforce to benefit from the new ways of working (such as telecommuting) and are critical factors to ensure that local women can increase their employability. • The above measures should help address work- and culture-related challenges as well.

Challenge	Policy recommendation
Challenge: The availability, transparency, and quality of (and accessibility to) gender-disaggregated data is inadequate to support the measurement of progress in the advancement of women in mining.	

Current datasets do not offer granular, gender-disaggregated sectoral data.	• Governments should consider putting in place a centralized data repository system using standardized gender reporting indicators for all economic sectors and to be used by all stakeholder groups. This platform would then provide publicly available centralized access to gender-disaggregated data for all sectors.
	 • Governments should ensure that their statistics bureaus and all concerned data agencies are set up for collecting and reporting on gender-disaggregated sectoral data.
	 • Governments and companies should reach an agreement on using ILO or appropriate international category standards to set the parameters on which gender-disaggregated data should be collected and reported such as:
	   • Recruitment and retention
	   • Occupation
	   • Local employment
	   • Remuneration and pay gap
	   • Skills levels
	   • Skills development, training, and mentoring
	   • Health and safety
	   • Local procurement
	   • Participation of women in decision making.

Current datasets lack an inclusive and intersectional lens which makes it hard to investigate policy impacts for marginalized or underrepresented groups and persons.	• Governments, boards of directors, and stock exchanges can mandate companies to report disaggregated data tables which allow for reporting in gender rather than sex, and inclusive of other indicators when ethically, legally, and culturally appropriate (i.e., Indigeneity, race, ethnicity, disability status, etc.). When such information is collected, the utmost respect should be paid to ensure the anonymity and protection of personal data. • Companies can adopt voluntary measures to report disaggregated data tables that allow for reporting in gender rather than sex, and inclusive of other indicators when ethically appropriate (i.e., Indigeneity, race, ethnicity, disability status, etc.)

Opportunity	Policy recommendation
Women's organizations, such as Women in Mining, can provide support, education, and connection for women in mining and their allies.	• Governments can offer funding to support women's organizations to hire and retain staff, thereby reducing dependency and risk of volunteer turnover. • Companies can fund women's organizations directly, support employees to contribute to women's organizations by offering paid volunteer time, and recognize volunteering activities in annual employee performance reviews. • Companies can collaborate with organizations working to improve gender equality policies in the mining sector, including Women in Mining organizations, to provide the equality, diversity and inclusion services and training lacking in their organizations.
There is a growing interest from the private sector to model and implement pilot projects and programs targeting the challenges listed in this report, but there is no monitoring and reporting available to measure the impact.	• Voluntary corporate policies and procedures on gender inclusivity and their performance need to be reviewed and evaluated internally, including by board members, shareholders, and external reviewers. Internally, mining companies need to have performance and strategy management processes and a regular reporting mechanism. Based on the data gathered and monitored, there should be mandatory regular reporting on the strategies, actions, and performances with respect to recruitment and retention, training, and the pay gap. • Disclosure agreements that can be made part of initial mining investment negotiations are crucial to ensure transparency and accountability and—most importantly—to raise performance standards. • Companies can become signatories to globally recognized standards bodies such as United Nations endorsed Women's Empowerment Principles or Gender Seal. • Good practices can be recognized and promoted by governments and the international community.

Concluding Remarks

Recommendations from the first phase of the WMF project include actions and policies that governments and companies can implement to increase the representation and retention of women working in the large-scale mining sector, which is evolving at an unprecedented speed.

It is difficult to precisely predict the outlook of the mine of the future as industries and their labour force undergo transitions due to technological innovation and the push for a greener economy. This first phase of the Mine of the Future Project focused on the analysis of existing trends in workforce composition and occupations in selected countries to understand the gendered status of different occupations and educational qualifications. Phase 2 of the WMF project will map the gender-disaggregated changes in occupational structures and skills requirements needed for future jobs in large-scale mining to further the recommendations from Phase 1. Phase 3 of the project will shed light in the implications of the changes in the mining sector on local supply chains, with an emphasis on women.

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Appendix A. Methodological Note

The methodological note includes a detailed description of each step that led to the cross-country analysis. The global report relied on the creation of baseline studies for the 12 countries selected, namely Argentina, Australia, Brazil, Canada, Chile, Colombia, Ghana, Mongolia, Peru, South Africa, Sweden, and Zambia.

The baseline studies were specifically designed to enable analysis across different databases and across different national contexts. The set of studies included:

1. Gender-disaggregated country data profiles as collected by the ILO, in particular household surveys and labour force surveys and through national statistics bureaus.
2. Country reports that provided country-specific diagnosis of policies and data related to employment, education levels, age, skills, the gender pay gap, and other critical profiles of women and men in the large-scale mining sector.

The unique methodology used for each of the steps outlined is detailed below, including the methodology used for the drafting of the final global report.

1. Gender-Disaggregated Country Data Profiles

With the support of the International Labour Organization (ILO), gender-disaggregated country data profiles on employment in the mining sector were produced for the 12 selected countries.

In order to generate the gender-disaggregated country data profiles of mine workers, data was extracted from the ILO database using:

1. Mining as an industry, as defined in the ISIC
2. Occupations relevant to the mining sector, as defined in the International Standard Classification of Occupations (ISCO).

The data used were from the national labour force surveys (LFSs), collected by national statistical offices and submitted to the ILO. LFSs are one of the primary national household sample surveys undertaken by countries. They are designed with the objective of producing official national statistics on the labour force, employment, and unemployment. The data is harmonized across countries by the ILO to ensure consistency in comparison. LFSs typically require large samples with complex sample designs. Analysis of LFS data thus requires the use of national weights and evaluation of associated sampling errors.

Where data was available, employment data for the mining industry were based on ISIC Code B for Mining and Quarrying, and included sub-sections (05) Mining of coal and lignite; (07) Mining of metal ores; (08) Other mining and quarrying and (09) Mining service activities, but excluded (06) Extraction of crude petroleum and natural gas. Time-series analysis was conducted for the years 2012, 2014, 2016, 2018, and 2020.

Country profiles were created at the industry level based on ISIC as defined by the ISIC code, for all countries except for Canada and Australia, where data were not available. Argentina was added as a country of interest at a later stage, but the data were discarded since the sample size was too small, and the results were found to be unrepresentative. The

country profiles described the mining workers by age, education, urban/rural, part/full time, permanent/temporary contract, public/private sector, status in employment, occupation group (ISCO 1-digit), formality of work, and (where available) hours, earnings, and migration status. These were all disaggregated by sex.

The final step was to examine occupation codes (ISCO) to identify and analyze the detailed occupations that existed in mining in three countries, namely Brazil, Mongolia, and South Africa. These countries contained data that were available at the most detailed ISCO 4-digit level. Time-series analyses were conducted for each country covering 2012, 2014, 2016, 2018, and 2020, in an effort to examine the relative movement of occupations over time, within the mining industry. This exercise was repeated at the national all-industry level, for referral, to provide a sense of the main occupation groups in these countries, at 1- and 2-digit ISCO levels. Furthermore, time-series reports were produced for all females at national level and for females in mining. However, the sample for females in mining was often small and unrepresentative, but, where possible, the occupations in this cohort were described.

The data extracted for these countries describe the occupations and their prevalence within the mining worker cohort. They are a starting point to track changes in some individual occupations of interest in the mining industry. However, there are limitations to this analysis. First, large obvious shifts of occupations take time to emerge and therefore it is difficult to make conclusions of trends for the period under review. Additionally, the ISCO coding is updated every 20 years, meaning that as occupation skills evolve over time they are not reflected in the classification during this period. For information, the latest ISCO update dates back to 2008.

2. Country Baseline Reports

National consultants with experience in the mining sector, research, data analysis, report writing, and fluency in the national languages were contracted to collect data for their respective baseline analyses and draft country reports. Consultants were asked to complete the following tasks:

1. Provide an inception report outlining the methodology and data collection structure for the study.

2. Collect gender-disaggregated data on the profile of workers in large-scale mining according to their occupational functions/roles, levels of responsibility, age, educational attainment, and technical capacities. Where available, data also include gender pay gap salaries.

3. Analyze the current situation of women in employment in large-scale mining.

4. Analyze women's working conditions at the workplace, including their social, health, and safety protections, and any particular prohibitions/exclusions, where relevant, including in national regulatory and legal frameworks and in international frameworks or conventions applicable in countries.

5. Analyze the gaps and discrepancies observed during data collection across different data resources and suggest improvement strategies for the collection and categorization of such data.

6. Prepare a country report that summarizes:

i. The policy and regulatory context in the country.

ii. Findings of the data analysis.

iii. Gaps and challenges that women face in the mining sector.

iv. Good practices that are implemented by mining companies and governments to overcome barriers faced by women.

v. A set of policy recommendations and guidelines to improve the participation of women in the sector.

Consultants participated in regular coordination meetings with the IGF to update on progress, share insights, and receive guidance on the research and analysis. The reports average 30 pages (excluding annexes and references), and each include an executive summary. They were reviewed by the project team before being completed and are publicly available for consultation.

Each country report details the main challenges encountered in the production of their baseline analyses and the specific obstacles they had to (or could not) overcome. They outline the gaps in data, policy, and practice for their specific context and country. However, the overall challenge encountered in the development of the final reports was the availability of data—or lack thereof. Consultants relied on officially collected and reported data and national statistics to get a portrait of women's participation in large-scale mining. Most country reports were able to gather data on the number of women in mining disaggregated by age, education levels, occupation levels, and skills over the past 10 years. This is the basis that allows comparison across the selected countries. However, not all reports could obtain gender-disaggregated data on some data points, such as geographical distribution of women and men employees, women's involvement in mining per phase of the mining cycle, or salary gaps, where such data was not available at national level. In some cases, proxy data was used. For example, in Sweden, the educational segregation was not available for the mining sector, and instead non-sector-specific data were studied to understand women's representation in mining-related STEM areas. In Ghana, country-specific inquiries were conducted to access granular data. In Peru, due to the limitations on data disclosure, the data from ILO and minerals council was used instead.

Demographic data collected at the national level are usually based on sex as opposed to gender, and as a result do not capture gender identity and diversity within the mining industry. This means that gender-diverse individuals such as trans people and non-binary people are not captured by the data, and neither are the social reality and norms that affect how they are perceived and treated in the workplace. The analyses in the country reports—and as a result the global report—very much remain divided along the female–male axis.

As of the drafting of the global report, the country reports were completed for Argentina, Australia, Brazil, Chile, Canada, Ghana, Mongolia, Peru, South Africa, and Sweden.

Appendix B. Literature Review on the Participation of Women in the Large-Scale Mining Workforce

Context Setting

The adoption of new technologies, while not new in mining, is predicted to fundamentally reshape the business and operating models of mining companies. New technologies are also expected to affect the breadth of opportunities for local suppliers and the development of local content and in-country value addition, although it is not clear what the balance of benefits against these challenges would be. While some new technologies may contribute to lowering the carbon footprint of mining operations and make mining safer for workers by decreasing exposure to risks and workplace accidents, they may have considerable impacts on the economic and social development opportunities of host communities by reducing opportunities for employment and local procurement.

The lack of consistent, granular, and gender-disaggregated data makes it challenging to forecast the impacts of technological disruption and increased mining activities on female participation in the mining workforce, in the mining supply chains, and in communities. It also makes it impossible to uncover the potential of women as drivers of the transition to a low-carbon future in the mining sector and to promote an industry that is equitable and sustainable for people, economies, and the environment. However, despite the absence of comparable and systematic baselines, many research projects and studies have attempted to address the state of play for women in the mining industry and pinpoint certain dynamics that shape opportunities and challenges for their participation in the sector. The literature review was conducted prior to the drafting of the WMF Global Report. It should be noted that data for the literature review were not equally available across regions and unfortunately cannot represent the variety of countries and contexts present in the global report. However, they still served as a brief overview of what is known about women's participation in mining and indicated data gaps in existing literature.

Historical Dominance by Men

Historically, women have worked or have been involved in mining since the early modern period (ILO, 2021). In the late 1800s, however, mining underwent drastic changes through the industrialization and mechanization of work, causing the gradual exclusion of women from the mining labour force. This can be partly explained by ideas of appropriate division of labour between women and men, which slowly took root in the mining industry. Compounded by the emergence of legislation meant to protect the safety of women and children at work, mining work has gradually become associated with male labour (ILO, 2021).

In 1935, the ILO Underground work (Women) Convention (No. 45) was adopted to prohibit the employment of women in underground mines. Up until the 1990s, the Convention gathered the signatures of 98 countries, which adopted different legal frameworks limiting or altogether banning the participation of women in mining, especially underground (ILO, 1935). For many, this prohibition was seen as a helpful development in safeguarding the health and well-

being of women (ILO, 2021). However, as understood today, conventions must equally protect women and men, and, therefore, it has been abrogated in favour of the Safety and Health in mines Convention, 1995 (No. 176) which looks to safeguard all mine workers irrespective of sex. While 30 countries have since denounced Underground work (Women) Convention (No. 45), it remains in force in many others.[24]

This historical prohibition has deeply affected the nature and extent of women's participation in mining. To this day, it is still perceived as men's work and remains one of the sectors most associated with, and dominated by, men. Multiple studies have attempted to map out the extent of female participation in large-scale mining. In 2009, the World Bank estimated that women made up 5% to 10% of formally employed workers in the extractive industries at large, including oil and gas (Eftimie et al. 2009). More recent research has looked at the data available on women's participation in the extractive industries in Canada, Australia, and South Africa. The findings in those reports contribute underscore how women are underrepresented in mining, including compared to other industries. At its highest point, it seems that the ceiling for women's participation in the extractive industries is around 20%, or one fifth of the workforce.[25]

The proportion of women working in mining is still mostly unknown as only certain governments or industries have invested the necessary resources to collect that data (Macdonald, 2017). Even in countries where data on women's employment in mining are collected and published, there is a lack of consistent methodology and occupation categorization that makes cross-country comparisons difficult.

Women's Employment Breakdown by Type of Occupation

Available data from Australia, Canada, and South Africa indicate that women tend to be vastly underrepresented in certain occupations. For instance, women accounted for much smaller proportion of technicians, trade workers, and machinery operations and drivers, while being more concentrated in clerical and administrative positions.[26] This suggests that overall participation rates of women in the mining labour force conceal dynamics of gendered division of labour. Men still tend to occupy jobs that are more physically challenging or that require mechanical and technical skills. Occupations that require field presence also seem to remain dominated by men (IGF, 2021).

Prior to the WMF research, a more detailed analysis of women's participation in the mining industry by occupation type across different countries was, unfortunately, impossible because of the lack of comparable data sets. Very few countries collect detailed gender-disaggregated data that include types of occupation and education. When that data is collected, it uses different methodologies and categorizes occupations in different ways,

24 The full list of countries with ratifications or denunciations can be found here.

25 In Canada, data dating back 2012 indicated that women represented 17% of the mining workforce (Macdonald, 2017). In Australia, women accounted for 16% of the mining workforce in 2018 (Work Gender Equality Agency, 2019). The Chamber of Minerals and Energy of Western Australia (CMEWA) (2019) found that women's participation in the extractive industries was around 20%. The Minerals Council of South Africa (2020) reported that in 2019, women represented 12% of the mining workforce.

26 In Australia, while making up 16% of the mining workforce, women accounted only for 4.5% of technicians. In Western Australia, women made up around 75% of clerical workers, while only accounting for 5% of technicians and trade workers (CMEWA, 2019).

which complicates any attempts at cross-country comparisons and makes the consistent identification of trends difficult (IGF, 2021).

The Leaky Pipeline

The leaky pipeline refers to a trend observed in specialized professions for which entry-level positions have a more equitable gender balance, but female representation decreases as women progress within these professions (Kenan Insight, 2021). Prior research on the phenomenon in academia and the corporate world indicated that high drop-off rates were not due simply to women's personal preferences; it has been attributed to implicit bias in the institutional policies and promotion systems, the prevalence of discrimination and harassment, and a workplace culture unwelcoming of women. In the mining sector, limited data from mostly Western countries is available, but existing research shows the presence of a drop-off rate of women from entry-level to senior management roles (McKinsey, 2021b). Indeed, women who enter the mining labour force quit the sector as they reach a certain level in their careers. From a sample of 1,000 male and female employees from Australia, Brazil, Canada, and the United States, McKinsey (2021b) found that women are leaving primarily because they find fewer advancement opportunities as their careers progress, especially in technical and leadership roles. The survey also indicated that women were more likely to leave the sector before reaching middle management, meaning that women in entry-level careers and beginning their professionalization in the sector were the ones most likely to consider leaving (McKinsey, 2021b). This survey was crucial in identifying the potential presence of a leaky pipeline in mining, but the available literature still lacks enough granular and representative data to understand the full extent of the leaky pipeline or its presence on a global scale.

The Harrier group, an Australian private group working in human capital management, released a report in 2019 looking at talent management and the inclusion of women in mining. They found that across Australia, men outnumbered women in almost all occupations and significantly more in site-based and leadership positions (Harrier, 2019). They estimated that the fly-in fly-out schemes and the commutes present a challenge for the progression of women in the sector. They also found that the majority of people holding CEO positions and senior operational roles have progressed from technical leadership, indicating that the high drop-off rate of women in the sector might lead to a lack of gender diversity at the senior management level.

Gender Pay Gap in Mining

The gender pay gap, defined by the UN 2030 Agenda as the difference between the salaries earned by women and men for work of equal value, has recently been the focus of research (UN General Assembly, 2015). The reasons for the gap between the wages of women and men can be attributed to their historical exclusion in the industry and inadequate labour policies, in addition to existing structural discrimination against women (ILO, 2021). While available literature was limited and could not be found across different regions and regional contexts, existing research indicates the presence of a gender pay gap in the mining industry in Australia and the United Kingdom. For instance, the average median gender pay gap in mining in the United Kingdom has been estimated at 25% (McKinsey, 2021b).

In Australia, the Chamber of Minerals and Energy of Western Australia (CMEWA) compiled data from the Workplace Gender Equality Agency indicating that the gender pay gap stood at 13.8% in 2019. Data from CMEWA provide insight into the variations of the gender pay gap across professions and contract types. Analysis shows that the resources sector has smaller gender pay gaps than national industry averages in all occupations except clerical and administrative, where most of the women are employed. There was also a significant gender pay gap among part-time workers, the bulk of whom were women (Macdonald, 2017; Workplace Gender Equality Agency, 2015). Although data from CMEWA show that the pay gap in mining was smaller than the average for 19 other industries, it may not be the most accurate representation of the gender pay gap in mining in other regions or countries. CMEWA uses annual gender pay equity audits as an indicator of progress in their diversity surveys, and the companies are reported to adopt policies and strategies on the gender pay gap as a result (Macdonald, 2017).[27] A thorough analysis of the gender pay gap per occupation, age, and contract type in other regions and countries is essential to understanding gendered dynamics and retention challenges in the sector.

Work Conditions

Workplace conditions at mine sites can easily be unwelcoming to women. The fly-in fly-out schemes requiring workers to be away from home for prolonged periods of time are not especially appealing for women, who must often shoulder other responsibilities or expectations at home, such as unpaid care work or looking after children and other family members. The long hours, safety risks, and the often remote and isolated worksites are also all contributing factors to making mining an unattractive option for women (IGF, 2021).

The lack of services and facilities provided for women also contributes toward making mining a hostile environment for women. This includes the often-mentioned lack of appropriate and adapted personal protective equipment (PPE), such as helmets, for women, who are often issued small men's sizes without consideration of any sex-based hygiene needs. In 2022, the Responsible Mining Index (RMI) reported that only a quarter of the 30 companies reviewed could demonstrate that they have systems in place to ensure that women are fitted with gender-appropriate equipment (Responsible Mining Foundation, 2022). The lack of female PPE results from the fact that companies buy PPE in bulk to save costs, or due to companies requiring PPE based on the type of hazard or risk encountered while working instead of anatomical difference between women and men (Hogan Lovells, 2015; Maphatsoe, 2021).

Additionally, companies often do not provide women-friendly facilities such as bathrooms, changing rooms, and sleeping accommodations, a fact exemplified by the 2022 RMI report, which noted that only a handful of companies could demonstrate having gender-appropriate sanitation facilities. Other types of facilities that could make mining a more welcoming environment for women are also absent, such as childcare facilities and breastfeeding rooms (IGF, 2021; McKinsey 2021b).

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27 The data from the Chamber of Minerals of Energy of Western Australia might be an exception to gender pay gap trends in the sector. As part of their reporting, CMEWA monitors companies conducting pay equity audits, and their strategy has displayed a dramatic increase in the number of companies undertaking gender pay gap analysis, which doubled between 2013 and 2019, and stands at twice the average for all other industries (CMEWA, 2015, 2019).

The lack of appropriate PPE and the absence of appropriate facilities, compounded by a heavily masculinized workplace environment, also create the circumstances for heightened gender-based violence against women (IGF, 2021). This fact seems to be underscored by the RMI report, which found that only half of the companies reviewed made mentions of having systems that protect women workers from intimidation, harassment, sexual harassment, and gender-based violence (RMI, 2022).

Workplace Culture

There is research documenting the recurrence of discrimination against women and other obstacles encountered by women in the male-dominated industry. Quoting a variety of research and sources published throughout the 2000s, Abrahamson et al. (2014) found that women in mining face the risk of one-on-one sexual harassment, being subjected to group offending behaviours, and generally sexist work environments. Those findings were recently confirmed by an external review conducted by the mining company Rio Tinto (Elizabeth Broderick & Co, 2022). Harassment has consequences for women, who often reported feeling unsafe or having to change their own behaviour by toughening up or "acting like men" (Abrahamson et al., 2014; Saunders & Easteal, 2013). Anderson (2012, quoted in Abrahamson et al., 2014) reported similar results from research in Luossavaara-Kiirunavaara Aktiebolag's mines. In addition to feeling isolated from other women, they were on the receiving end of sexist remarks implying that mining was too dangerous, demanding, or technical for them. Harassment is reported to create unsafe, unsupportive, and even threatening environments for women. It causes distress, disrupts concentration, has a negative impact on employee well-being, and increases turnover of staff (International Finance Corporation, 2018).

Other forms of discrimination could include pervasive myths about women in mining. For instance, in some regions of the world, women working underground are considered a "bad omen" and are believed to cause misfortune at mine sites. Myths can be associated with women's menstruation, with beliefs that women have bad luck while on their period, influencing whether women feel welcome and capable of working in mining (Chenjerai, 2019).

As mentioned above, there seems to be a correlation between workplace culture and the retention of female personnel in mining. McKinsey (2021b) noted that the women surveyed referred to "not being a member of the boy's club" to be a contributing factor to their decreasing motivation and feeling of belonging. Women also reported finding it twice as difficult to adapt to the culture of mining compared to men, and those who found workplace culture not supportive of diversity were also twice as likely to want to leave the sector.

New Technologies, Energy Transition, Environmental, Social, and Governance Requirements, and Their Expected Impacts on Women

Literature on the adoption of new and disruptive technologies in the mining sector seems to suggest these will have gendered impacts and will affect women's already unequal participation in the mining workforce. Mining operations are expected to be less labour intensive and physically challenging as technologies might take over heavy duties. As many countries still ban women from working in underground mines, remote operations could improve women's access to certain types of jobs and operations. It could alter the way mining

operates and replace the fly-in fly-out model along with other challenges women encounter in remote areas, such as the lack of facilities adapted to their needs.

At the same time, new technologies have the potential to bring new (or heighten existing) inequalities. New mining technologies might increase the demand for employees with STEM-related educations and skills, of which women make up only 27% of graduates globally (WEF, 2016). The distribution of female STEM graduates also varies widely from country to country. For instance, In South Africa, women made up 43% of STEM graduates in 2017, whereas in Chile this percentage was only 19% (World Bank Gender Data Portal, 2022). Another anticipated impact of new technologies on women in mining is that they will likely rely on digital literacy and access to the Internet. There is a digital gender divide between women and men that affects women's digital literacy. Globally, it is estimated that men more often access mobile phones and the Internet (IGF, 2021). This divide is even more pronounced in developing countries (World Wide Web Foundation, 2020). While new technologies might present an opportunity for women with high education and skills, they might not offer such opportunities to women in mining communities (IGF, 2021). To quote the IGF's New Tech, New Deal report, these dynamics raise the question of "whether we will just be replacing a traditionally masculine mining sector [...] with a new kind of masculinity that manifests itself in digital literacy, skills, and resources" (IGF, 2021).

Concluding Remarks

The existing literature paints a portrait, albeit incomplete, of the gendered power dynamics present in mining. A few assumptions can be teased out from what is known of women's involvement in mining:

1. The large-scale mining sector is small compared to other economic sectors.
2. Large-scale mining is a highly masculinized sector.
3. Working conditions are not conducive to women's employment.
4. Women are underrepresented in certain occupations and overrepresented in others.
5. Women lack mining-specific skills and education.
6. Women quit large-scale mining at a younger age.
7. The gender pay gap persists in the mining workforce.

Understanding the current state of women's participation, the obstacles they encounter, and their reasons for not entering or leaving the mining labour force is the first step toward identifying the main dynamics behind women's absence in the sector. This report seeks to use the data generated to complete and nuance what is known of women in mining and draw additional findings from women's employment data.

Appendix C. Maternity Leave Policies

TABLE C1. Summary of maternity, paternity, parental, and breastfeeding provisions in study countries (2022)

Country	Maternity leave	Paternity leave	Parental leave	Breastfeeding breaks
Argentina	12 weeks	2 days	52 weeks, either	2 half hour breaks
Australia	18 weeks	2 weeks	52 weeks, either	None
Brazil	120 days Ext. 180 days	5 days Ext. 20 days	None	2 half hour breaks until 6 months old
Canada	17 weeks (15 weeks in Alberta)	Entitled to parental leave	40 weeks, either parent	Allowed, unpaid
Chile	18 weeks	5 days	12 weeks	1 hour break until 2 years old
Colombia	14 weeks	8 days	None	2 half hour breaks until 6 months old
Ghana	12 weeks	None	None	1 hour until 12 months old
Mongolia	120 days	None	N/A	2 hours until 6 months old; 1 hour until 1 year old
Peru	14 weeks	4-10 days	None	1 hour until 1 year old
South Africa	4 months	3 days	None	2 half hour breaks
Sweden	90 days	90 days	480 days to be split between parents, minus 90 days reserved for each parent	Guaranteed with no age limit for the child
Zambia	12 weeks	None	None	2 half hour breaks until 6 months old

TABLE C2. Mining company parental policies operating in study countries (2022)

Company	Coverage	Maternity leave	Paternity leave	Parental leave	Breastfeeding breaks
Anglo American	Australia	18 weeks	2 weeks		
BHP	Global	18 weeks	2 weeks	Can be split between parents if they both work for BHP.	
CODELCO	Chile	18 weeks, Ext. 24 weeks	5 days		2 half hour breaks until 2 years old
Compania Minera Poderosa S.A.	Peru	98 days	10 days		
Rio Tinto	Global	18 weeks	1 week*	*By 2023, secondary careers will be entitled to 18 weeks.	
Vale	Brazil	180 days	20 days		
	Australia	120 days	14 days		

TABLE C2. Mining company parental policies operating in study countries (2022)