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OekoRess II: Country Case Study VIII

Botswana: Nickel (Selebi-Phikwe)

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Abstract

The project "Further development of policy options for an ecological raw materials policy" (OekoRess II) builds on the results of two preceding research projects, UmSoRess and OekoRess I. It links experiences gained in the analysis of environmental and social standards with the assessment of environmental risks in the mineral resources sector. The project team conducts 10 case studies to evaluate and refine the method to assess site-related environmental hazard potentials posed by mining operations, which was developed in the OekoRess I project. The focus is on improving the indicator for environmental sector governance, by comparing the assessed environmental hazard potentials, the observed environmental impacts and the governance analysis with existing governance indicators. The aim is to answer the questions whether existing governance indices and indicators are able to adequately reflect the capacity of governments, companies and civil society to manage potential environmental hazards and avoid or reduce environmental impacts of mining.

This case study analyses the potentials for environmental hazards and the environmental impacts of the nickel mine Selebi-Phikwe in Botswana, which was in operation until 2016. The main environmental impacts identified were the large land footprint, the resulting effects on biodiversity (e.g. fragmentation of animal habitats), the contamination of water and soil (high concentration of heavy metals and presence of acid mine drainage) and numerous negative health effects. Most of the site-related environmental hazard potentials, identified by the OekoRess methodology, adequately point to the identified environmental impacts. Only the high environmental hazard potential for the indicator "use of auxiliary substances" could not be confirmed.

Existing governance indices and indicators adequately reflect Botswana's overall average sector governance. Some indicators, such as the Worldwide Governance Indicator "Control of Corruption" seem to portray Botswana's mining governance slightly too positive. While environmental and health legislation in the mining sector is in fact advanced, implementation is sometimes lacking.

Kurzbeschreibung

Das Vorhaben „Weiterentwicklung von Handlungsoptionen einer ökologischen Rohstoffpolitik" (ÖkoRess II), welches auf den Ergebnissen zweier vorangegangener Forschungsprojekte (UmSoRess und ÖkoRess I) aufbaut, verbindet Erfahrungen aus der Analyse von Umwelt- und Sozialstandards mit der Bewertung von Umweltrisiken im Rohstoffsektor. Das Projektteam führt 10 Fallstudien durch, um die im Rahmen des ÖkoRess-I-Projekts entwickelte Methode zur Bewertung standortspezifischer Umweltgefährdungspotenziale im Bergbau zu evaluieren und weiterzuentwickeln. Der Fokus liegt auf der Verbesserung des Indikators für Umwelt-Governance, indem die bewerteten Umweltgefährdungspotenziale, die tatsächlichen Umweltauswirkungen und die Governance-Analyse mit vorhandenen Governance-Indikatoren verglichen werden. Ziel ist es, die Frage zu beantworten, ob die Governance-Indikatoren in der Lage sind widerzuspiegeln, inwiefern relevante Akteure (Regierungen, Unternehmen und Zivilgesellschaft) potentielle Umweltgefährdungen bewältigen und Umweltauswirkungen des Bergbaus vermeiden oder reduzieren können.

Diese Fallstudie analysiert die Umweltgefährdungspotenziale und die tatsächlichen Umweltauswirkungen der Nickelmine Selebi-Phikwe in Botswana, die bis 2016 in Betrieb war. Die wichtigsten festgestellten Umweltauswirkungen waren: Ein großer Flächenbedarf, die daraus resultierenden Auswirkungen auf die biologische Vielfalt (z.B. Fragmentierung tierischer Lebensräume), Wasser- und Bodenverschmutzung (v.a. hohe Konzentration von Schwermetallen und saure Grubenwässer) sowie zahlreiche negative Auswirkungen auf die Gesundheit. Die meisten standortbezogenen Umweltgefährdungspotenziale, die durch die ÖkoRess-Methodik identifiziert wurden, decken sich mit den tatsächlichen

Umweltauswirkungen. Das hohe Umweltgefährdungspotenzial für den Indikator „Verwendung von Hilfsstoffen“ konnte jedoch nicht bestätigt werden.

Die bestehenden Governance-Indizes und -Indikatoren spiegeln die durchschnittliche Umwelt-Governance in Botswana angemessen wider. Einige Indikatoren, wie der Worldwide Governance Indikator „Control of Corruption“, scheinen Botswanas Bergbau-Governance etwas zu positiv darzustellen. Die Umwelt- und Gesundheitsvorschriften im botswanischen Bergbausektor sind zwar weit fortgeschritten, doch es mangelt weiterhin an der Umsetzung.

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List of Abbreviations

AMD	Acid Mine Drainage
ASM	Artisanal and small-scale mining
AZE	Alliance for Zero Extinction
BCL	Bamangwato Concessions Ltd.
BEAPA	Botswana Environmental Assessment Practitioners Association
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe (German Federal Institute for Geosciences and Natural Resources)
BMWU	Botswana Mine Workers Union
BOFEPUSU	Botswana Federation of Public Service Unions
CPI	Corruption Perception Index
CSR	Corporate Social Responsibility
DEA	Department of Environmental Affairs
Debswana	Debswana Diamond Company Ltd.
DGS	Department of Geological Survey
DPSIR	Driving forces, Pressures, States, Impacts and Responses
EIA	Environmental Impact Assessment
EIAA	Environmental Impact Assessment Act
EPI	Environmental Performance Index
ESP	Economic Stimulus Programme
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GSHAP	The Global Seismic Hazard Assessment Program
IUCN	International Union for Conservation of Nature
LSM	Large-scale mining
MEWT	Ministry of Environment, Wildlife and Tourism
MMA	Mines and Minerals Act
MMEWR	Ministry of Minerals, Energy and Water Resources
NBSAP	National Biodiversity Strategy and Action Plan
NDP	National Development Plan
OekoRess	Research Project 'Discussion of ecological limits of raw materials production and development of a method to evaluate the ecological availability of raw materials with the aim of further developing the criticality concept'
UmSoRess	Research Project 'Approaches to reducing negative environmental and social impacts in the production of metal raw materials'
UNESCO	United Nations Educational, Scientific and Cultural Organization
USGS	United States Geological Survey

WGI	Worldwide Governance Indicators
WSI	Water Stress Index
WWF	World Wide Fund For Nature

1 Focus of the study and relevance

The following is the eighth of ten case studies that are being prepared as part of the project "Further development of policy options for an ecological raw materials policy" (OekoRess II), commissioned by the German Federal Environment Agency. The case studies build on the results of two previous research projects, the UmSoRess[1] project and the OekoRess I[2] project. In UmSoRess, the impacts of raw material production on the environment, society and the economy were analysed in 13 case studies.[3] The goal of the case studies was to gain a better understanding of the connections between the environmental and social impacts of mining in the context of various countries with different problems and governance contexts. In OekoRess I, a method to evaluate the ecological availability of raw materials and the site-related environmental hazard potentials posed by mining operations was developed, with the aim to further develop the criticality concept.

As part of the follow-up project OekoRess II, 10 additional case studies will be conducted, combining the analytical approaches of UmSoRess and OekoRess I in order to evaluate and further develop the method to assess the site-related environmental hazard potentials posed by mining operations, which was developed in the OekoRess I project. This effort will particularly focus on improving the indicators for environmental sector governance used in the methodology, by comparing the assessed environmental hazard potentials, the observed environmental impacts and the governance analysis with existing governance indicators. The aim is to answer the question if existing governance indices and indicators are able to adequately reflect the capability of governments, companies and civil society to manage environmental hazards and avoid or reduce environmental impacts of mining. The results of the 10 case studies will be compared and a set of governance indicators will be identified that can be used to improve the raw-material-specific assessment approach developed as part of the OekoRess I project.

This case study analyses the environmental hazard potentials and the environmental impacts of the nickel mine Selebi-Phikwe in Botswana and the countries´ mining governance. The mining sector is one of Botswana's most important industries and accounts for about 90% of the country's total export value. Diamonds, nickel and copper are Botswana's three most important commodities, accounting for approximately 94% of the country's total commodity production (BGR 2014). In October 2016, the loss-making mine was closed and put under liquidation. The search for a new operator or investor is still ongoing (Business Day 2016). In Selebi-Phikwe, air pollution and health risks from extraction and melting activities have been identified in the past. An action catalogue was compiled by the mine operator, but it is unclear to what extent the environmental damage could be reduced. Alternative uses for the mine site are currently being sought.

The case study is divided into four parts: First, the structure of the mining sector of Botswana and its contribution to the national economy is analysed (chapter 2). Second, a brief overview of the Selebi-Phikwe mine is given. The geographic and geologic context is analysed, followed by an overview of the applied mining and processing methods (chapter 3). Third, the environmental hazard potentials posed by the mining operation is discussed using the site-related OekoRess methodology, and selected environmental impacts and reactions to these are described using the DPSIR framework that was also used

[1] Approaches to reducing negative environmental and social impacts in the production of metal raw materials. For more information see https://www.umweltbundesamt.de/umweltfragen-umsoress

[2] Discussion of ecological limits of raw materials production and development of a method to evaluate the ecological availability of raw materials with the aim of further developing the criticality concept. For more information see https://www.umweltbundesamt.de/umweltfragen-oekoress

[3] The case studies and fact sheets on the standards and approaches analysed can be accessed here: https://www.umweltbundesamt.de/umweltfragen-umsoress

in the UmSoRess case studies (chapter 4).[4] Fourth, the governance of Botswana's mining sector is analysed (chapter 5) and last, the findings of the assessment of the environmental hazard potentials and environmental impacts as well as the governance analysis are compared to existing governance indicators and indices and first conclusions for the methodology development are drawn (chapter 6).

[4] The DPSIR framework comprehensively accounts and visualizes the causal connection between environmental issues, their origin, their impacts and the responses taken. The model consists of driving forces, pressures, state, impacts and responses. For further information see e.g. Kristensen (2004).

2 Structure and macroeconomic relevance of Botswana's mining sector

Since the early 1980s, the mining industry has provided the greatest contribution of all industrial sectors to Botswana's gross domestic product (GDP) (World Bank Group 2016). More precisely, the mining sector accounts for around one quarter of Botswana's GDP, which amounts to 13.09 billion USD in 2016 (LIPortal 2017; World Bank Group 2016; USGS 2017). However, the information provided by the German Federal Institute for Geosciences and Natural Resources (BGR 2014) differs from the other three sources. It estimates the raw materials sector's share of GDP being only 16.9% for 2014. With this result, BGR (2014) assigns Botswana the 66th rank worldwide regarding its importance as a mining country. The GDP from mining decreased in 2009 due to the great depression and has not recovered since (Trading Economics 2018). Nevertheless, in 2016, 89.9% of Botswana's total export value resulted from the mining sector and revenues from the export of mining products accounted for 35% of the state revenue (World Bank Group 2016). Besides mining, other important economic sectors are public services, financial and business services, tourism, construction, transport and social services. Agriculture in Botswana is primarily for self-sufficiency and therefore contributes only little to the national GDP (Export.gov 2017).

The data on the significance of mining for the Botswana labour market are inconsistent. According to the World Bank Group (2016) the mining industry provided 3.2% of formal employment[5] in 2015 which, in absolute figures, corresponds to 12,773 employees. USGS (2017) and sources therein speak of 23,783 workers in 2014 in the mining and quarrying sector (formal employment). Artisanal and small-scale mining (ASM) activities in Botswana are limited to few operations that produce "agates, aggregates, bricks, dimension stone and gold". Exact information about the number of mines, capacity and production was not available (USGS 2017).

According to the World Bank Group (2016) Botswana is rated an upper middle-income country. This status is mainly owed to the diamond industry. Diamonds are the main commodity mined, accounting for 53% of all prospecting licenses issued in Botswana in 2008. Since the discovery of diamonds half a century ago, this resource has accounted for most of the country's steady and significant growth rate. Before the discovery of diamonds, Botswana was a deeply poor country with only a few industrial bright spots (World Bank Group 2016). Botswana distances itself strongly from trade with conflict diamonds (LIPortal 2017) and is a participant of the Kimberley Process - a system to ban conflict diamonds from the global supply chain. The Kimberley Process Certification Scheme certifies diamonds as conflict-free and safeguards a traceable shipment (Kimberley Process 2017).

In 2016, 89.9% of Botswana's total export value stemmed from the mining sector. Of this percentage, in turn, 85.4% came from diamond mining (World Bank Group 2016). Of the 35% of the state revenue resulting from mining, 79% is accounted for by diamond production. These figures show how much Botswana's prosperity depends on diamond mining (LIPortal 2017). However, diamond production has declined due to lower global demand and falling commodity prices. Therefore, the country is currently focusing on the development of large coal reserves and base metals to offset its reliance on diamonds. Following diamonds, copper and nickel is the second most important mineral product for Botswana. Copper and nickel accounted for 4.5% of Botswana's total export volume in 2016 (World Bank Group 2016). Diamonds, nickel and copper are Botswana's three most important commodities, accounting for approximately 94% (diamonds 60%) of the country's total commodity production (BGR 2014).

In addition to these three main commodities, the mining and extraction of other minerals such as co-

[5] Figures are not available for informal, unlicensed artisanal or small-scale miners.

balt, gold, soda ash, salt and coal also contribute to Botswana's economic income (LIPortal 2017). According to BGR (2014), mineral resource production in Botswana was 2.5 billion USD. Furthermore, Botswana's share of world mining production in 2014 was as follows: For diamonds 19.8%, for nickel 0.7%, for soda ash 0.5%, for copper 0.3% and lower amounts for salt, coal, gold and cobalt.

Table 2-1: Mineral production in Botswana 2014

Mineral	Production 2014		
	Volume [in 1000 t] (unless otherwise noted)	% of ∑ World	Rank (own calculation)
Diamonds (in million carats)	24.7	19.83	1
Copper	47.4	0.26	30
Nickel	14.9	0.64	19
Cobalt (in t)	196	0.15	19
Soda Ash (natural)	250	0.48	5
Salt	515.3	0.18	38
Coal	1,711.6	0.02	unknown
Gemstones (in million carats)	16	21.59	2

Source: BGS (2017); USGS (2015); Waves (2016); own calculation.

The raw material price for nickel has been tending to fall since a peak in 2011 (BGR 2016). Botswana's share of the world nickel reserves is 1.2% (BGR 2014). According to USGS (2016), the nickel production of the country in 2013 was approximately 22,848 t (ore milled). BGR figures for 2013 differ from those of USGS. According to BGR approx. 30,000 t of nickel were mined in 2013 (BGR 2014) with a decrease in production to 23,800 t in 2015 (BGR 2016). Table 2-2 shows nickel production as well as Botswana's world share in nickel mine production between 2013 and 2015.

Germany is one of the world's five major consumer countries for the industrial metals aluminium, lead, copper, nickel and tin. 7.9% of German imports of raw materials originate from Africa. With regard to the use of refined nickel, Germany accounted for 3% of the global nickel consumption in 2015 (BGR 2016).

In Botswana, the mining of minerals is strictly controlled by the government. The state owns all mining rights and grants authorisations for the extraction and marketing of mineral resources where appropriate. However, some smaller private companies, especially Canadian ones, have recently acquired prospecting licenses in Botswana. Yet, companies mostly work closely with the 50% state-owned Debswana Diamond Company Ltd (Debswana, formerly De Beers Botswana Mining Company) (LIPortal 2017). Norilsk Nickel was also active in Botswana, but sold its shares to Bamangwato Concessions Ltd (BCL). Due to the closing of the Selebi-Phikwe mine, it was no longer possible for BCL to comply with the purchase agreement (Business Day 2017). The Mining and Mineral Acts (1999) states that companies explore possible deposits on their own risk and are only able to apply for a mining license afterwards in a second step (Matshediso 2005).

Table 2-2: Nickel mining in Botswana and world share, 2013-2015

Nickel mining in Botswana	2013	2014	2015
Nickel mine production (tons)	22,848	14,958	16,789
% of ∑ World	0.82	0.64	0.74
World mine production	2,790,000	2,350,000	2,280,000

Source: USGS (2018).

3 Overview of the mining operation and geology in Selebi-Phikwe

Selebi-Phikwe is a large nickel and copper mine in eastern Botswana, consisting of the three excavation sites Selebi, Selebi North and Phikwe. The three sites form along a single mafic band of mineralization over an interval of 15 km (Porter Geoconsultancy n.d.). The total nickel deposits comprise about 531,000 t (Maier et al. 2008).

In 2014, the mine production generated 30,000 t of nickel, 25,000 t of copper and 400 t of cobalt. Ore mining started in 1973, following the discovery of ore deposits around Selebi and Phikwe in 1963. The mine was run by Bamangwato Concessions Ltd until a decline in copper quality and price led to its closure in 2016.

After several investigations, the authorities placed the mine under provisional liquidation as it was not possible to cover the costs of about 713 million USD to recapitalize the project. A special committee was created in 2018 to identify the barriers that hampered the revitalization of the "Selebi-Phikwe economic programme" (MMEGI online 2018). As of June 2018, with the help of the investment promotion company SPEDU, the government of Botswana is looking for ways to find investors for the mine site – also in order to create job opportunities. Negotiations were held with the Brite Star aviation group, which planned to establish an aircraft assembly plant, a research centre, a maintenance workshop, hospitality facilities and a pilot training centre in Selebi-Phikwe (Kelebeile 2018). However, no decisions were made for the time being.

3.1 Geography

The spatial area of the Republic Botswana amounts to 582,000 km^2. The number of inhabitants was estimated at 2.2 million in 2016, with an annual growth rate of 1.2%. Botswana is located in southern Africa, surrounded by Zimbabwe (east), Namibia (northwest) and South Africa (south). The country on average lies at about 1000 m above sea level with the highest mountains being the Tsodilo Mountains (1489m).

Southern Botswana is characterized by the Kalahari Desert, also known as the "sand desert". Of the several periodic rivers that form natural borders with the country, the Okavango and the Kavango are the best known. The Okavango Delta is a UNESCO World Heritage Site and famous for its immense ecological value. Northern Botswana is characterized by fertile land, called the "hard meadow", which is found to the east and south of a vast plateau. This landscape contrasts with the salt flats of Magkadigkadi in northern Botswana, with less than five percent of the arable land located in this region of the country (Asare and Darkoh 2001; LIPortal 2017).

The Selebi-Phikwe mine is located in eastern Botswana, as shown in Figure 3-1. Here, the temperate, climate and loamy clay soils have a positive influence on the fertility of the land in this region. Savanna grasslands dominate the landscape, with a low proportion of small forest areas (FAO 2005).

Figure 3-1: Map of Botswana

Source: CIA World Factbook (2004).

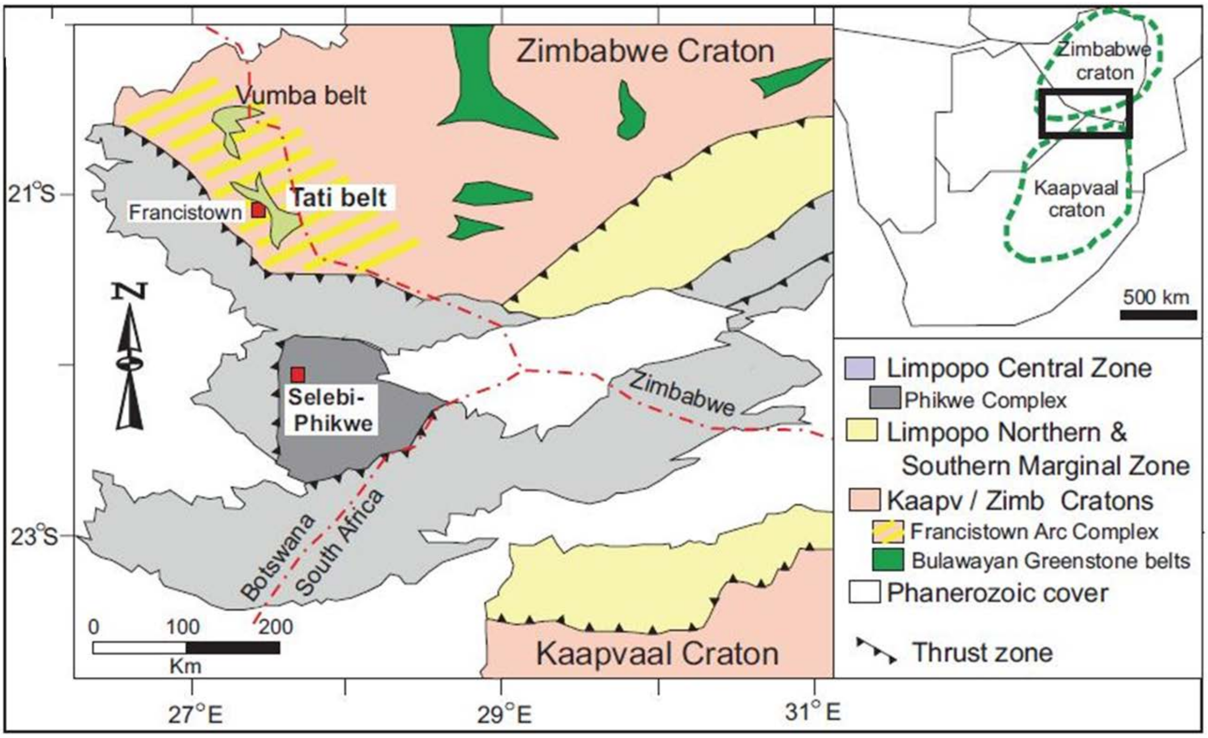
Day temperatures in Botswana can reach 40°C in summer, while temperatures fluctuate strongly in winter (5 to 23°C). The climate of the Selebi-Phikwe region is semi-arid, with an average temperature of 21°C and temperatures below the national average (Schwartz and Kgomanyane 2007). Most rainfall is to be expected in the period from October to April, partly associated with storms. The average annual rainfall is 450 mm/a (Schwartz and Kgomanyane 2007).

Semiarid regions are characterized by low rainfall and high evapotranspiration rates: The latter are highest in summer, when more than 80 percent of annual rainfall occurs (FAO 2005).

3.2 Geological context and development of ore deposits

Botswana's east and southeast is dominated by rocks from the archaic period. Selebi-Phikwe in eastern Botswana lies in the Palaeoproterozoic Limpopo belt, partly covered by Karoo rocks and Kalahari sediments, and located between the Kaapvaal and Zimbabwe Cratons (Figure 3-2) (Maier et al. 2008). It comprises several Archean terranes that are between 3.2 and 2.6 billion years old. In addition, large sedimentation sequences and large centres of magmatism were recorded during the Paleoproterozoic. The development of the Limpopo belt at this age has not yet been fully clarified (Schlüter 2006).

Figure 3-2: Map of relevant tectonic units.

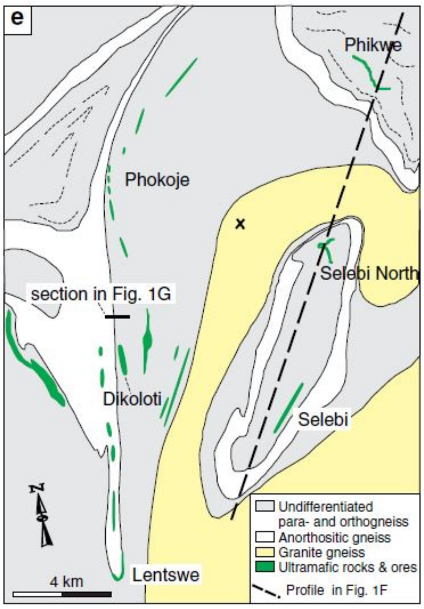


Left: Map of tectonic units of the triangle Botsuana, Zimbabwe and South Africa and location of the Selebi-Phikwe mine in the context. Upper right: Overview of the regional embedding of the left figure. Source: Maier et al. (2008).

The most common rocks in the Phikwe complex are various types of gneisses as well as amphibolites and gneissic granites (McCourt et al. 2004; Fiorentini et al. 2012). Early metamorphosed paleoprotein-rozoic rocks, such as fine-grained to medium-grained amphibolite interlayered with gneisses, contain the Ni-Cu-(PEG)-sulfide ores. Nickel is a siderophile element and is usually found in oxidic minerals. Nickel ores can also be extracted from sulphidic minerals, as it is the case in Selebi-Phikwe (ibid.). In the amphibolites and especially at the contact with the gneisses, massive sulphides of up to 38 m thick-ness occur. As shown in Figure 3-3, there are three more deposits (Dikoloti, Lentswe and Phokoje) in the Selebi-Phikwe area. In addition, the host rock at Selebi-Phikwe contains chalcopyrites and chalco-cites containing Cu while pentlandites are a major source of Ni (Ekosse 2008).

The three mines Selebi, Phikwe (Phikwe and Southeast Extension) and Selebi North have total ore re-serves of 45 Mt (0.97-1.50% Cu, 0.86-1.362% Ni). Together, the six deposits are also referred to as the "Phikwe Intrusion Belt". The nickel content of the reserve is approximately 531,000 t (Maier et al. 2008). Due to its toxicity, nickel is classified as a heavy metal (Thakur 2013).

Figure 3-3: Locations of deposits in the Selebi-Phikwe area



Source: Maier et al. (2008).

3.3 Mining and Processing

The various types of ore bodies in the Phikwe complex, namely veins, tabular bodies and massive bodies, are mined underground by stoping. Specifically, either open stoping (MacGregor 2004) or cut and fill is performed. The stoping technique is used when the host rock is strong enough to permit drilling and blasting processes and to resist collapse in the excavated open space ("the stope"). The stope is carved out stepwise, moving from bottom to top. The excavated space is either left open (open stoping) or back-filled (cut and fill).

In Selebi-Phikwe, the ore material is transported to the crusher via a rail and crushed and ground in several steps (Mulaba 2007). The subsequent flotation and magnetic separation results in a concentrate of approx. 3.5% Ni and 4.75% Cu. This concentrate is pumped into the BCL smelter as slurry.

The BCL smelter is located in the mining complex, where not only ore from BCL's Selebi-Phikwe mines is processed, but also ore from Tati Nickel and South African Nkomati Nickel. Flash smelting of the slurry is carried out in an Outokumpu furnace, a process originally developed for copper smelting (Warner et al. 2007; Godirilwe 2016).

In the Outokumpu furnace, the material is smelted with oxygen-enriched air (31% Vol. %) which is injected into the smelted material. Blisters containing 74% Ni and Cu with 22% sulphur or 92% Ni and Cu with 6% sulphur are obtained this way and separated from the slack in a bath at the bottom of the furnace (Warner et al. 2007; Godirilwe 2016).

The waste material is finally stored in two tailing dams near the Phikwe mine, which contain about 300,000 tonnes of nickel. It is estimated that 50% of this nickel can be recovered by secondary mining methods (MMEGI online n.d.).

4 Overview of environmental hazard potentials and impacts

4.1 Environmental hazard potentials

As part of the OekoRess I research project an evaluation scheme for assessing the environmental hazard potentials (EHPs) of the extraction of primary abiotic raw materials was developed. This evaluation scheme is based on indicators, which are assigned to three levels of consideration. These levels are geology, technology and site surroundings. The level "Geology" comprises five indicators, which include environmental factors inherent to the geology on site. These key influencing factors are "precondition for acid mine drainage (AMD)", "paragenesis with heavy metals", "paragenesis with radioactive components", "deposit size" and "specific ore grade". The second level is "Technology" and includes the indicators "mine type", "use of auxiliary substances", "mine waste management" and "remediation measures". The third level "Site (surroundings)" comprises the indicators "natural accident hazard due to floods, earthquakes, storms, landslides", "Water Stress Index (WSI) and desert areas", and "protected areas and Alliance for Zero Extinction (AZE) sites". Furthermore, the indicator "conflict potential with local population" focusses on the social context. The latter indicator is further developed by analysing ten case studies of which the present case study is one.

The environmental hazard potential for each indicator can be rated as low (green), medium (yellow) or high (red) (for detailed information on the method see Dehoust et al. 2017b). Table 4 1 shows the evaluation of the EHPs of the Selebi-Phikwe mine, which are described in detail below.

The assessment of the EHPs of the Selebi-Phikwe mine is followed by an analysis of the actual situation and impacts of the mining activities on the environment as well as the responses from the mine site operator, the responsible authorities as well as the local communities, using the DPSIR framework (Chapter 4.2).

Table 4-1: Site-related OekoRess assessment

Thematic Cluster	Indicator	Environmental hazard potential		
		low	medium	high
Geology	Preconditions for acid mine drainage (AMD)			X
	Paragenesis with heavy metals			X
	Paragenesis with radioactive components	X		
	Deposit size			X
	Specific ore grade		X	
Technology	Mine type	X		
	Use of auxiliary substances			X
	Mining waste management			X
	Remediation measures			X
Site (surroundings)	Natural accident hazard due to floods, earthquakes, storms, landslides	X		
	Water Stress Index (WSI) and desert areas			X
	Protected areas and Alliance for Zero Extinction (AZE) sites	X		
	Conflict potential with local population		X	

4.1.1 Geology

Preconditions for acid mine drainage (AMD)

Nickel is a siderophile element and is usually found in oxidic minerals. However, nickel ores can also be present in sulphidic minerals, which are a greater hazard. As the Selebi-Phikwe mine extracts nickel from sulphidic ores, the mine's acid mine drainage potential is high (*high environmental hazard potential*).

Paragenesis with heavy metals

Nickel is defined as a hazardous heavy metal because of its toxicity (Thakur 2013), accordingly the environmental hazard potential of heavy metals from nickel mining is high. Also copper-bearing minerals such as chalcopyrites and chalcocites are present, adding to the yet high risk for environmental hazard potential for heavy metals (*high environmental hazard potential*).

Paragenesis with radioactive components

Maier et al. (2018) describe the composition of Ni–Cu–(PGE) sulfide deposits, among them Selebi-Phikwe. For Selebi-Phikwe several rock sample where analysed with regard to their geochemical composition. Uranium (U) and thorium (Th) values for these samples where applied to the procedure of the site-related ÖkoRess measuring instructions. The result did not show an increased environmental hazard potential for radioactivity. It should be mentioned, though, that a Wikipedia article states that uranium deposits werefound in 2009 in Serule (Wikipedia 2017), a village east of the mining town Selebi-Phikwe (*low environmental hazard potential*).

Deposit size

Nickel is one of Botswana's most important mineral resources (BGR 2014). In 2013, almost 30,000 tonnes were mined at the Selebi-Phikwe mine, with the total deposits at the Selebi, Selebi North and Phikwe mines amounting to around 45 Mt of ore (Maier et al. 2008). The nickel content of the reserve is approximately 531,000 t (Maier et al. 2008). With regard to the size of the deposits the Ni-Cu mine can be classified as showing a high hazard potential (*high environmental hazard potential*).

Specific ore grade

The Selebi-Phikwe belt contains 1-3% nickel (Maier et al. 2008). Nickel deposits with an ore content of >2% are rich ore deposits and between 0.5 and 2 is an average ore content. Therefore, this indicator shows a medium hazard potential for the Selebi-Phikwe mine (*medium environmental hazard potential*).

4.1.2 Technology

Mine type

In the Selebi-Phikwe mine, cut-and-fill extraction methods, open stope breast mining and various types of open stope mining are used. These mining methods are deep mining processes and do not disturb the surface to the same extent as open mining operations. For this reason, the mining methods used have a low environmental hazard potential (*low environmental hazard potential*).

Use of auxiliary substances

Mining at the Selebi-Phikwe site is carried out by drilling and blasting. These methods are among those extraction and processing methods involve additives but not of toxic nature. The ore processing, however, involves a flotation process. Processing that includes flotation is evaluated with a high environmental hazard potential, as long-chain organic hydrocarbons with toxic characteristics and a high resistance to degradation are often used. The environmental hazard potential is therefore determined to be high (*high environmental hazard potential*).

Mining waste management

No significant information is available on the disposal of waste at the Selebi-Phikwe mine. As a result of the backfilling process during the excavation process, at least part of the waste is stored underground. However, the size and dimension of the Selebi-Phikwe mine and its long life span led to the construction of two tailing dams near the Phikwe Shaft, clearly visible on satellite images. Their size is approximately 1.6 x 1.0 km and 0.9 x 0.4 km, with an estimated height of the larger dam of up to 40 m. Evaluation of satellite images suggests that the tailing storage facilities have been in operation until recently. The tailings are a major sources of water pollution due to seepage. The seepage water shows elevated values of SO_4^{2-} (5,680 g/L) and heavy metals (6,230 µg/L Ni, 1,860 µg/L Cu and 410 µg/L Co) (Schwartz and Kgomanyane 2007). Tailing storage facilities were also built at the shafts Selebi and Selebi North. Based on this information, the waste management represents a high hazard potential for the environment (*high environmental hazard potential*).

Remediation measures

So far, no concrete remediation plan has been drawn up. With the help of the investment promotion company SPEDU, the government of Botswana is looking for ways to find investors for the mine site – also in order to create job opportunities (as mentioned in chapter 3). For this reason, there is a high environmental hazard potential (*high environmental hazard potential*).

4.1.3 Site (surroundings)

Natural accident hazard due to floods, earthquakes, storms, landslides

The total natural disaster risk is assessed by analyzing four individual sub-indicators. All sub-indicators (earthquakes, floods, tropical storms, landslides) show a low environmental hazard potential. The evaluation is carried out in acordance with the measurment instructions, which suggest to use georeferenced data from publicly available risk maps. The results are taken directly from the given risk assessment. The indicator total is derived by the highest hazard potential of the sub-indicators. These include earthquakes, landslides, floods and storms. The Selebi-Phikwe is not located in a seismically active area (GSHAP world MAP) therefore the earthquake risk is low. Although parts of Botswana are occasionally flooded by the Limpopo River, the Selebi-Phikwe mine is not affected because of its long distance (about 120 km) to the river. Moreover, neither landslides nor storms are a risk. The environmental hazard potential of natural disasters is therefore considered to be low (*low environmental hazard potential*).

Water Stress Index (WSI) and desert areas

The WSI by Pfister et al. (2009) provides characterization factors on the relative water availability at watershed level. The indicator combines this information with an evaluation whether the site is located in a desert area. Mining operations often need large amounts of water for the operation. Depending on the hydrological situation, a competition for water between the different users can occur. The evaluation was carried out in accordance with the procedure described in the measurement instructions (Dehoust et al. 2017a). Botswana has increasing water consumption due to human settlements (FAO 2005). According to WWF classification, Selebi-Phikwe is not located in a desert region, but the water stress index is high (>0.5) (*high environmental hazard potential*).

Protected areas and Alliance for Zero Extinction (AZE) sites

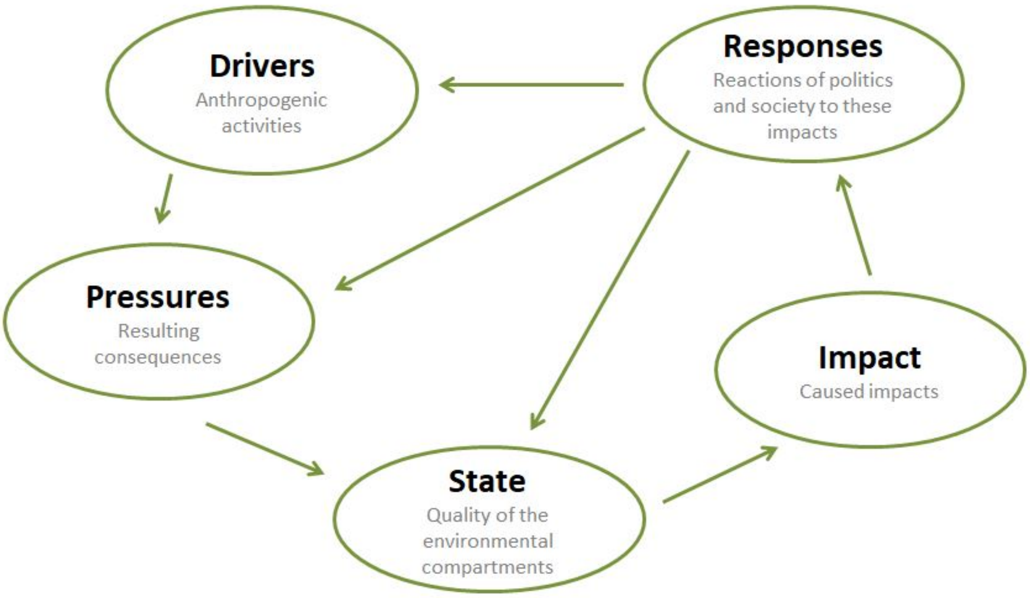
Georeferenced data for designated protected areas are used to assess hazards posed by mining extraction. The metric to evaluate EHPs corresponds to the method first described in the draft standard of the Initiative for Responsible Mining Assurance (IRMA 2014). The mine is not located in protected or highly protected areas. Therefore, the environmental hazard potential from operation in protected areas is low (*low environmental hazard potential*).

Conflict potential with local population

The governance indicators "control of corruption" and "voice and accountability" indicate a percentile rank of 80.29% and 59.11%, for 2016 (World Bank 2017). Consequently, the environmental hazard potential associated with weak governance can be classified as medium (*medium environmental hazard potential*).

4.2 Environmental impacts

Figure 4-1: DPSIR Framework



Source: Own preparation, based on Kristensen (2004).

The DPSIR framework is a systemic analytical approach to better understand the interaction of humans and their environment in order to derive adequate policy measures. It comprehensively accounts for and visualizes the causal connections between human activities, the resulting consequences for the environment and the responses of humans. The model consists of driving forces, pressures, state, impacts and responses.[6]

This chapter deals with the environmental impacts of mining, ore processing and smelting in the Selebi-Phikwe mining area. The focus is on land use and biodiversity, air pollution, water and soil contamination and the negative impacts of nickel mining on human health.

4.2.1 Pressures

[6] For further information on the DPSIR framework and its elements see Kristensen (2004).

The main pressures in the area stem from the mine itself, as well as from the tailings facilities and the smelter.

The industrial use of the land and the construction of infrastructure required to operate the mine led to the transformation of natural landscapes, which was exacerbated by the subsequent migration of workers and urbanisation. Tang et al. (2016) estimate a transformed area of $1m^2$ for each tonne of nickel metal produced in Botswana's underground mines, considering only the pit itself, the tailings and the dumps. Since the mine opened, Selebi-Phikwe's population has grown rapidly from 5,000 in 1971 to 18,000 in 1975, 29,000 in 1981 and 49,000 in 2011 (Asare and Darkoh 2001; Statistics Botswana 2015).

4.2.2 State and Impact

Land use and biodiversity

Despite the lack of studies investigating the specific environmental impact of the mining operation on biodiversity, it can be assumed that the already outlined general changes in land use and population density have led to fragmentation of habitats and displacement of wildlife.

Regarding the direct impacts on flora and fauna, research for the area of Selebi-Phikwe region is lacking. However, according to the findings of Ekosse et al. (2005), leaves of Mopane trees in the surrounding area of the mine and the smelter/concentration plant showed concentrations of heavy metals from wash-offs, particulate air matter, "plant uptake from soils, and other wastes due to mining activities."

Water and soil contamination

The slag from the smelter, which contains sulphide ore, is dumped at tailings near the mines. These tailings are major sources of water pollution due to seepage. This seepage water shows elevated values of SO_4^{2-} (5,680 g/L) and heavy metals (6,230 µg/L Ni, 1,860 µg/L Cu and 410 µg/L Co) and a high acidity caused by AMD (Schwartz and Kgomanyane 2007). Studies have shown that the soils near the smelter/concentrator are heavily metal-contaminated from wash-offs, due to weathering and wind erosion. The concentration of heavy metals in the soil on the windward side of the plant is higher than on the leeward side of the plant (Likuku et al. 2013). Contamination seems to decrease with increasing distance to the site (Ekosse et al. 2005). Residents, NGOs and government departments attribute the contamination of soil and drinking water to the discharge of wastewater into the environment and acid mine drainage (AllAfrica 2016a; Asare and Darkoh 2001). Farmers have difficulties to grow or farm on their land as the fertility of soil around the mine decreased (Mokgethi 2016; Ramaphane 2016b). According to Asare and Darkoh (2001), soil fertility was severely degraded by 2001, which had a negative effect on crop cultivation of local farmers in the Selebi-Phikwe area.

Air emission and pollution

Smelter emissions contain heavy metals and sulphur dioxide (SO_2) which are spread by aerial transportation (Ekosse et al. 2004b) and result in air pollution and the contamination of soils. Besides the emissions from the smelting process, the most important atmospheric emissions of the mining complex are the nickel-rich dusts produced during ore crushing. Exhaust gases with an SO_2 content of 20% are released into the air and distributed by the wind. At high concentrations, this gas can be harmful to both human health and vegetation (IEMA 2012).

Health

The health of residents and workers in the Selebi-Phikwe area is severely affected by the direct and indirect impacts of pollution. The emitted sulphur dioxide in Selebi-Phikwe has caused health problems in particular for the respiratory system (All Africa 2016a). Studies show a connection between the risk to suffer from health problems and the distance to the mine and the smelter plant (All Africa 2016a).

Plants absorb heavy metals enriched in the air and are consumed by humans, used as medicines or fed to farm animals. In this way, pollutants are transferred to humans who are also directly exposed to the air emissions of the smelter (Asare and Darkoh 2001; Ekosse et al. 2005; Vogel et al. 2006; Ekosse 2008; Ekosse 2011). The particulate air matter, which contains heavy metals and gases such as SO_2 and H_2S, affects the respiratory tract and causes coughing, shortness of breath, suffocation, and chest pain. Congestion, diarrhoea, abdominal pain, weight loss, headaches and recurring colds are likely to be caused by the consumption of contaminated food and air pollution (Ekosse 2008). Death of workers occurred at several sites in the Selebi-Phikwe region, and is mainly due to cardiopulmonary complications. It is assumed that fatal diseases such as cancer and lung diseases are related to emissions in the area (Ekosse 2008). The factors mentioned, caused by mining and smelting activities, among other things, can contribute to the negative health effects in Selebi-Phikwe, although there is a lack of studies, as mentioned above.

4.2.3 Responses

Responses of the mining company

The European Development Fund funded a consortium advising BCL and the Botswana government. Based on the Environmental Impact Assessment (EIA) of air quality, recommendations for measures to reduce air pollution from smelting processes have been given (IEMA 2012).

BCL declared in 1998 to comply with the following plan to protect the affected environment of Selebi-Phikwe:

“a) Monitor on a continuous basis the effect of its operation on the environment both within the plant and outside its boundaries. This will involve all aspects of the company’s operations from purchasing and engineering design to daily operations.

b) Comply with all relevant environmental protection legislation whilst striving to achieve the highest attainable environmental standards in all operations.

c) Aim to minimise the use of all materials and energy. Wherever possible renewable or recyclable materials and energy sources will be used.

d) Minimise waste and effluent produced in all parts of the business and aim for “waste free” processes.

e) Adopt and aim to apply the principle of “sustainable development”. Development, which meets the needs of the present, without compromising the abilities of future generations to meet their own needs.

f) Expect similar environmental standards to our own from all third parties involved in our mining operations - suppliers, vendors, and contractors. While we cannot impose our standards on the companies, we can favour those who comply.

g) Adopt an environmentally sound transport strategy."

h) Liase with and solicit the views of the local community in matters of common interest."

(Asare and Darkoh 2001)

In the past, the Botswana government could not force the BCL to implement the above-mentioned policy (Asare and Darkoh 2001). It remains unclear to what extent BCL has been able to advance in the achievement of these self-developed environmental protection goals in recent years.

5 Governance

5.1 Sector governance, regulation and effectiveness of national institutions

Overview

Botswana's mining sector is mostly praised as being well-developed providing a comprehensive legal and regulatory framework in particular compared to other African countries. The Botswanan government seeks to promote a business-friendly environment for the mining sector in general and for the exploration of diamonds in particular. The key mining legislation – the Mines and Minerals Act (MMA) – fosters national production as well as national benefits and revenues and offers clear guidance as regards mining permits and concessions. Furthermore, the country has been recognised for its management of mining revenues which are reinvested e.g. in education and health care. However, the mining sector also shows some weaknesses regarding the implementation of health and safety standards and the prosecution of violations which is reflected in the case of BCL. Furthermore, the implementation of environmental legislation has shown limitations amongst others due to capacity shortages and missing technical expertise within the responsible monitoring agency, the Department of Environmental Affairs (DEA).

Institutional and administrative framework

The Ministry of Minerals, Energy and Water Resources (MMEWR) is the key actor for the supervision of operations and developments in the mining sector in Botswana (KPMG 2014). Within the MMEWR, the Department of Mines organises all activities in the context of mining such as the preparation of mining policies, the execution of relevant legislation, safety control and the enhancement of "socio-economic, financial and other benefits to Botswana arising from the exploitation of mineral resources" (MMEWR 2018a). The MMWER's Department of Geological Survey (DGS) manages geo-specific information and "assist[s] the Director of Geological Survey in the administration of the relevant parts of the Mines and Minerals Act" (MMEWR 2018b).

The Department of Environmental Affairs (DEA) at the Ministry of Environment, Wildlife and Tourism (MEWT) is a key actor responsible for environmental aspects relevant for the mining sector. Amongst the DEA's responsibilities falls the promotion of "sustainable development by coordinating the protection of the country's environment and the conservation of its natural resources" (AfDB 2012).

Legal and regulatory framework

Botswana underlines long-term sustainable development in its national Vision 2036 (2016-2036) and includes a pillar on sustainable environment and the "optimal" use of natural resources.[7] Vision 2036 is implemented by Botswana's latest National Development Plan 11 (NDP) 2017-2023, which aims at "Inclusive Growth for the Realisation of Sustainable Employment Creation and Poverty Eradication". The NDP 11 explicitly formulates the national goal to expand mining activities underlining the importance of the sector for the country's economic development (MFDP 2016).

All rights of mineral resources are owned by the Botswanan Republic. However, mining projects in tribal territories must additionally respect the Mineral Rights in the Tribal Territories Act of 1967. The

[7] Vision 2036 proclaims: "By 2036 sustainable and optimal use of natural resources will have transformed our economy and uplifted our people's livelihoods. This pillar includes the ecosystem functions and services, sustainable utilization of natural resources, water security, energy security, sustainable land use and management, sustainable human settlements, climate resilience and disaster risk reduction and pollution and waste" (MLG 2018).

Act notes the transfer of mining rights from the Botswanan tribes and their authorities to the Botswanan State under specified conditions determined for each tribe (Government of Botswana 1967).

The main legislations governing the mining sector are the MMA of 1999[8], the Mines and Minerals Amendment Act of 2005 and the Mines, Quarries, Works and Machinery Act of 1971. The MMA regulates mineral resources' exploration and the related rights and provisions (AfDB 2012). The exploration of petroleum is administered by a separate act (Government of Botswana 1999a). The MMA covers prospecting licences, retention licences, mining licences, mineral permits and mineral concessions and surface rights as well as financial provisions and environmental obligations. The permission for mineral concessions depends on certain land restrictions (e.g. formulated in the Tribal Territories Act) and must be approved by the president or the rightful owner of the land (Government of Botswana 1999a).

The MMA grants the Botswanan government a central role in the mining business by giving it the possibility to obtain a minority stake usually of 15% in mining companies (KPMG 2014; Government of Botswana n.d: Section 40). However, in some diamond projects the government holds shares of up to 50%. It also had a 94% interest in BCL limited (MMEWR n.d.)[9]. According to the MMEWR this participation in mining companies offers the Government the possibility to promote local ownership in the respective mining projects (MMEWR n.d.).

In addition, the MMA provides for the representation of the government on the board of mining projects (KPMG 2014).[10] The minister of the MMEWR himself is also attributed various rights. A prospecting license for example can only be renewed beyond the maximum seven-year period upon his decision (LEX Africa 2017). Apart from that, the minister is furthermore assigned certain responsibilities for instance to promote the efficient "investigation and exploitation of mineral resources of the country" to benefit the country (KPMG 2014).

Most of the MMA's sections include provisions that support the national economy and national benefits as well as favourable investment conditions (Bookbinder and Peo 2015). This directly corresponds to the MMEWR's minerals policy objective to "[m]aximize the economic benefits for the nation while enabling private investor to earn competitive returns" (MMEWR n.d.). Regarding its policy approach the MMEWR stresses its commitment to enable favourable conditions for mining projects with notably low taxation, security for mining operators to proceed from the exploration to the mining phase, security for profits of investors, and "[c]lear and streamlined licensing procedures" (MMEWR n.d.).

Further details on mineral concessions, the payment of royalties and penalties are offered by the Mines and Minerals Regulations. As regards the health and safety of employers in the mining sector, the MMA as well as the accompanying regulations contain a number of provisions for instance on accidents (Government of Botswana 1999b). In cases of deadly incidents or serious wounding caused by mining operations, the MMA legitimates inspectors to carry out investigations. The regulations define a "safety and health code" and accompanying minimum requirements for mining operators, supervisors and employers (Bookbinder and Peo 2015). However, in the case of BCL the implementation of these standards and the prosecution of non-compliance by mining operators through the Government have shown significant weaknesses (see chapter 5.2).

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[8] "Exploration and exploitation of minerals governed by the Mines and Minerals Act first enacted in 1969 with revisions in 1976 and 1999" (MMEWR n.d.).

[9] Botswana's government now seems to hold only 7.5% of BCL shares (BCM 2018)

[10] It could not be verified whether the government generally requires representation at board level for all mining projects or just certain mining projects. KPMG (2014) states: "The legislation allows the government to acquire a minority stake (generally 15 percent) in mining projects as a partner and seek participation in the mining projects by having representation in their boards."

Furthermore, health and safety standards for mining and technical equipment used are governed through the Mines, Quarries, Works and Machinery Act of 1971 (LEX Africa 2017) and the corresponding regulations of 1978 (Government of Botswana 1978b). The Act covers amongst others accidents (Government of Botswana 1978a). The World Bank Group (2016) estimates the MMA as providing "a clear regulatory framework for the licensing of mineral development in Botswana" and giving details on concessions. Furthermore, there are discussions on a revised Mines and Minerals Act planned to be adopted in summer 2018 (Xinhua 2018; Heer 2017). According to the director of a coal mine and lecturer for mining at the University of Botswana, the draft is supposed to offer a more comprehensive policy and to modernise amongst others the environmental obligations (Heer 2017).[11]

Botswana has a progressive spending policy of mineral revenues, which are generally not "used to finance recurrent spending (with the exception of health and education)", but invested in physical and human capital (AfDB 2016; Tsena n.d.).

Corporate Social Responsibility in the mining sector

KPMG (2014) observes a lack in policies prescribing Corporate Social Responsibility (CSR) measures for mining companies. While CSR legislation exists in other countries[12], a binding regulation does not exist in Botswana. However, there are examples of CSR activities implemented by mining companies in Botswana. In 2008, BCL received public acknowledgement of the Minister of Lands and Housing for its community development efforts notably infrastructure development in Selebi-Phikwe (MMEGI online 2008).

Environmental legislation relevant to mining

Environmental legislation and policy is primarily covered by the National Conversation Strategy of 1991, the Wildlife Conservation and National Parks Act of 1992, the National Biodiversity Strategy and Action Plan (NBSAP) of 2016 and the Environmental Assessment Act (EIA Act)[13] of 2011 and the accompanying Environmental Assessment Regulations of 2012. Different other legislations also include environmental aspects e.g. the Waste Management Act of 1998, the Guidelines for Disposal of Waste by Landfill or the Mines, Quarries, Works and Machinery Act, which recommend the conduct of EIAs but does not make them mandatory by law (AFDB 2012).

The National Conversation Strategy of 1991 aims at ensuring sustainable development in Botswana. The Strategy's goals are particularly focussed on the effective use and conservation of natural resources, e.g. the goal to prevent and control pollution (AfDB 2012). The Wildlife Conservation and National Parks Act was enacted in 1992 to protect wild species and ecosystems. It prohibits mining activities in national parks under certain conditions[14] (Government of Botswana 1992). A more recent environmental strategy is the NBSAP of 2004, updated in 2016. The NBSAP includes the protection of biodiversity and ecosystems and lists mining as a cause for "[c]hanges to hydrology and water quality of inflowing rivers" (Government of Botswana 2016).

In Part IX of the MMA, the act mentions environmental obligations related to rehabilitation and recla-

[11] No further information on the draft or the revision of the MMA in general was available by August 2018.

[12] The EU directive 2014/95, for example, obliges European companies to report on social and environmental aspects in their activities.

[13] The text of the first version of the Act from 2005 is called the „Environmental Impact Assessment Act, 2011". Given that most sources call it the Environmental Impact Assessment Act (EIA Act), this text uses the acronym EIA Act.

[14] "Subject to any mining rights lawfully acquired in any area by any person before the date on which such area became a national park, any prospecting or mining in the area or the acquisition of any prospecting or mining rights in the area in terms of the Mines and Minerals Act shall be prohibited except with the written permission of the Minister" (Government of Botswana 1992).

mation as well as the provision of an EIA in order to obtain a mining license. However, some provisions remain vague. This includes obligations for mineral concession holders to preserve the environment "as far as possible" and the obligation to „*minimize* and control waste or undue loss of or damage to natural and biological resources" (Government of Botswana 1999a). During the prospecting phase, a licence holder must present "proper provisions for environmental protection" and put the land used for the prospecting operations in its old condition towards the end of the prospecting license (Government of Botswana 1999a). In case of non-compliance the government can carry out the restoration and charge the license holder with the costs. Holders of mining licences and mineral permits are obliged to develop and conduct their mining activities in accordance "with good mining and environmental practice" (Government of Botswana 1999a). The EIA Act, which was adopted in 2005 and revised in 2010, is the most relevant environmental legislation for the mining sector. On the one hand, the EIA act is targeted at estimating environmental impacts of development projects and defining suitable countermeasures. The act requires EIAs for exploration and mining activities. On the other hand, the act focuses on establishing a monitoring processes and evaluation system regarding environmental impacts (LEX Africa 2017). In this context, the EIA act provides details on the process of EIAs. The revision of the EIA act introduced more details e.g. on reporting in order to make EIAs more efficient. Similarly, accompanying regulations published in 2012 further detailed the process. The revised EIA act for example introduced the Botswana Environmental Assessment Practitioners Association (BEAPA), a non-profit institution mandated with the certification and registration of qualified Environmental Assessment Practitioners (Tshwene-Mauchaza 2015; BEAPA n.d.). The registration with the BEAPA is mandatory for all Practitioners conducting EIAs. Another modification to EIAs can be found in Section 3(3) of the revised Act, which "empowers the minister to exempt projects from the EA [environmental assessment] process at his/her discretion". Detailed criteria for such an exemption are however not defined (Tshwene-Mauchaza 2015).[15]

The DEA serves as the authority for the execution of the EIA Act (Tshwene-Mauchaza 2015). Amongst the DEA's four divisions, the Environmental Assessment and Audits Division controls and administers EIAs and their implementation (AFDB 2012). The DEA charges fees for the review of project briefs and the reviews of EIAs (Mining and Travel 2012).

However, the implementation of the EIA Act is partially ineffective due to capacity shortages and inefficiencies of the responsible institution, the DEA. Tshwene-Mauchaza (2015) identifies three major weaknesses:

First, the human resources capacities at the DEA are not sufficient "to monitor, audit and enforce compliance". The limited number of DEA officers of approximately 18 spread across six offices across the country does not allow for the monitoring of all development projects. Furthermore, the shortage of technical expertise within the DEA and the lack of cooperation with other stakeholders – e.g. with other specialised agencies– pose additional difficulties for the monitoring.

Second, the DEA and its officers are not completely independent. The exemption clause in Section 3(3) of the EIA Act (see above) is decided by the Minister of the MEWT. Yet, the DEA's director works under the authority of the minister and might therefore find it difficult to formulate potential reservations to the exemption to his immediate supervisor.

Third, the BEAPA shows a fragile financial funding structure, which puts its long-term existence at risk. With merely 100 members, only a small part of the organisation's income is generated by member registration fees and subscription costs. The majority of funding (90%) stems from governmental grants making the BEAPA highly dependent. Furthermore, the BEAPA's registration requirements are limited

[15] Some justify the exemption clause with the safeguard of national security e.g. in emergency situations „such as having to construct fences as barriers during Foot and Mouth Disease outbreaks." (Mining and Travel 2012).

("a 'qualification in an environmental discipline' or in an environmental impact assessment course as the minimum for registration") and thus hamper a diverse, interdisciplinary technical expertise needed amongst the Practitioners (Tshwene-Mauchaza 2015).

Because of these weaknesses, implementation processes are significantly slowed down leading to potential negative impacts for the environment. Furthermore, there have been only rare cases of legal prosecutions in cases where the EIA Act's obligations were breached (Tshwene-Mauchaza 2015). For example in the case of BCL, the company has not yet rehabilitated the mining site leaving amongst others the Motloutse River polluted. Instead, BCL has used a share of its financial reserves designated for the rehabilitation of the mining site for operating costs (Mokgethi 2016; Seccombe 2017).

Artisanal mining governance

According to the Department of Geological Survey at the MMEWR, artisanal and small scale mining (ASM) is endorsed by the government (Kajevu 2013). The MMA considers ASM by distinguishing between large-scale mining (LSM) and small-scale mining provisions for mineral permits (World Bank 2016). However, information on ASM activities could only be found for "agate, aggregates, bricks, dimension stone, and gold" (USGS 2017) but not for nickel. A possible explanation is a general lack of data on ASM activities (USGS 2017; World Bank Group 2016).

Illegal mining, corruption and transparency

Illegal mining activities in Botswana occur e.g. in the sand (Segaetsho 2013) and in the gold sector (Mosikare 2016). Illegal gold mining is often driven by poverty and takes place in old, abandoned mines causing security risks to miners (Mosikare 2016) while illegal sand mining mostly occurs at rivers leading to negative environmental impacts (Kajevu 2013; Segaetsho 2013). No information could be found on illegal mining activities in Botswana's nickel sector.

Overall, Botswana, including its mining sector, shows very low levels of corruption, which is partially due to high wage levels of civil service agents (World Bank Group 2016). However, the African Development Bank criticises some incomplete data and a lack of transparency concerning mineral revenues of companies and the lack of timely publishing of details on revenue spending.

Furthermore, for large scale mining projects the government is criticised of not taking community needs serious e.g. regarding land use (World Bank Group 2016).

5.2 Social context of mining and conflicts

Overview

Most conflicts around mining in the Selebi-Phikwe area are of social or economic nature. They arose around the closure of the Selebi-Phikwe mine and smelter and the high number of unemployed miners that followed. This includes accusations of mismanagement against BCL. However, additionally, environmental conflicts emerged. Local residents suffer from the negative consequences of the Selebi-Phikwe mine and smelter such as contaminated water and the release of sulphur dioxide effecting the environment and causing health problems. This has led to allegations against BCL of having missed to rehabilitate the land and against the Botswanan government, which is accused of having ignored the environmental impacts of the mining activities in the region.

Mining conflicts

Botswana has a young population. In 2017, more than half of Botswanan people were under the age of 24 (Index Mundi 2018). In the same year, the unemployment rate reached 18% (Statista 2018). Unemployment and job losses have been key topics of conflict at the Selebi-Phikwe mine. In the course of the mine closure, more than 4,400 workers lost their job. A big part of them left Selebi-Phikwe to return to their villages of origin. The Botswana Mineworkers Union's Selebi Phikwe branch stated that six of these workers committed suicide (Mguni and Cohen 2016). Frustrations amongst the miners who lost their jobs in the course were even bigger considering that the main reason for BCL's insolvency was poor management (Seccombe 2017).[16]

Similarly, inadequate safety and health management at the mine site led to conflicts between miners and BCL. In 2016, four mineworkers died and six were seriously wounded in an accident. According to the Botswana Mine Workers Union (BMWU) eleven workers had already lost their lives in 2014 and 2015 due to poor safety standards. Workers and the BMWU fought for higher safety standards. In denouncing inadequate maintenance of machineries and the lack of resting days for workers at the mine, the workers and the BMWU addressed both, BCL and the government (The Botswana GAZETTE 2016; Kelebeile 2016). BMWU assumed a subordination of safety for the sake of higher profits by the BCL management (Mosikare and Kgoboge 2016). In response to accidents at BCL, the MMEWR started an investigation (The Botswana GAZETTE 2016).

In light of its close ties to mining companies and its shares in mining projects (see chapter 5.1.), the public has raised concerns regarding the impartiality of the Botswanan government. First, the government has likewise been criticised for its lack of transparency regarding the details of selling and privatizing the BCL mine (Ramaphane 2017). Therefore, the Botswana Federation of Public Service Unions (BOFEPUSU) has considered taking the Government to court (JournalduCameroun.com 2017). Second, Selebi-Phikwe residents claim that the government did not keep its promise to control and regulate the negative impacts of mining operations on the Selebi-Phikwe community despite numerous studies that were conducted showing the negative environmental impacts of nickel-copper mining to the disadvantage of the local population. Some examples are emissions causing problems for the respiratory system (All Africa 2016a) or the contamination of soil and water decreasing the fertility of farming land in the area (Mokgethi 2016; Ramaphane 2016b). Against this backdrop, community leaders from the Selebi-Phikwe region have considered to sue the Botswanan Government for "failing to protect them from mining emissions as well as other negative environmental impacts" (Ramaphane 2016b) accusing the Government of not having thoroughly assessed health and environmental implications of the BCL mining project (Mokgethi 2016). Business Botswana, a business association representing Botswanan employers from various sectors has set up a task team to „investigate circumstances surrounding BCL closure" and its implications. The task team criticises that neither an EIA nor a study on the socio-economic implications was conducted before the closure of the mine (Gaofise 2017). Furthermore, residents have considered to take BCL to court for not having properly rehabilitated the mining site. The need to rehabilitate the mining site also poses an obstacle to the perspective of selling the Selebi-Phikwe mine. The "environmental liability of more than 3-billion pula" (approximately 246.4 million EUR[17]) discourages investors (Seccombe 2017). This in turn reduces the chances of a re-opening of the mine and the reemployment of former workers. However, the lack of a closure plan and thus missing details on resulting obligations for BCL and a lack of clearance whether the Selebi-Phikwe mine will permanently close or be sold have represented obstacles to a legal prosecution (Mokgethi 2016).

Conflict Management

In response to the social and economic distress in the Selebi-Phikwe region after the closure of the mine, the government introduced various initiatives. The programmes and activities mainly focus on job creation and community support such as infrastructure development. As part of the Economic

[16] BCL rejects accusations against its management and reasons instead that the mine had come to the end of its "life span" (Tsena, n.d.)

[17] Converted with OANDA on 07.08.2018.

Stimulus Programme (ESP) several primary schools in the region are planned to be renovated and equipped (Mongwa 2018). The Government's efforts to boost local economy development in the Selebi-Phikwe region have brought some benefits to local businesses, one of them "made up of former BCL Mine employees who grouped themselves to form a company" (AllAfrica 2016a). An additional focus of the government lies on an economic restructuring from a region with a former high employment in the mining sector to a region with more jobs in other industries such as „agriculture, tourism, manufacturing and information technology" (Mguni and Cohen 2016). The planned financial resources sum up to 655 million pula (about 54 million EUR[18]) from the government, 1.1 billion pula (about 90.35 million EUR[19]) from the private sector (Mguni and Cohen 2016) as well as additional funds from development initiatives e.g. by the European Union (Ramaphane 2016a). The Government's "Selebi Phikwe Economic Revitalization Strategy" aims at the creation of 6,856 jobs in the region between 2016 and 2018. However, workers and the mineworkers' union have doubts that any effort by the government can replace the economic value and importance, which the BCL mine and its operations had in Selebi-Phikwe (Ramaphane 2016b). Furthermore, the Government's endeavours to find a private investor for the BCL mine are seen critically: "The government is accused of privatizing BCL without consultation and [without] following proper democratic steps to dispose a national asset of BCL's magnitude" (Ramaphane 2017)[20].

[18] Converted with OANDA on 07.08.2018.

[19] Converted with OANDA on 07.08.2018.

[20] Some critics go even further: "WeekendPost gathered from BCL liquidation critics that government had long wanted to privatize BCL but wanted to trick employees and Batswana by staging a fake insolvency" (Ramaphane 2017). However, it should be noted that corresponding critical statements could only be found in articles by Ramaphane and therefore should be treated with caution.

6 Conclusion and comparison of the analysis with existing governance indices

In this final chapter, the findings of chapter 4 (environmental hazard potentials and environmental impacts) and chapter 5 (governance analysis) are analysed to answer the following research questions:

- Does the assessment of the environmental hazard potentials adequately point to the actual environmental impacts?
- Are existing governance indices and indicators able to adequately reflect the governance capability to cope with the challenges arising around the environmental hazard potentials and environmental impacts of mining? In other words, are the identified governance gaps reflected in existing governance indices and indicators?

In order to answer the second question, a number of indices and indicators (see Table 6-1) were chosen based on a screening of a wide range of existing governance, environmental governance, and peace and conflict indices.

The results of this case study will be compared with the results of nine additional case studies that are conducted as part of this project as well as the case studies conducted in UmSoRess and OekoRess I. By comparing the findings of the case studies, a set of governance indicators will be identified that can be used to improve the assessment approach to analyse the environmental hazard potentials of the OekoRess I project.

Does the assessment of the environmental hazard potentials adequately point to the actual environmental impacts?

Only limited sources and data were available regarding the environmental impacts of nickel mining and processing in the Selebi-Phikwe area. The assessment of both, environmental hazard potentials and environmental impacts, was thus in parts based on literature on general environmental hazard potentials and impacts of nickel extraction.

The main environmental impacts outlined in this study were: first, the high use of land and the effects on biodiversity, namely the high concentration of heavy metals and the presence of acid mine drainage in the surroundings of the mine and the smelter/concentration plant. Second, the contamination of water and soil, which affects vegetation and soil fertility, thereby harming crop cultivation in the Selebi-Phikwe area. Third, numerous negative health effects possibly caused by heavy metals and SO_2 and H_2S emissions from the smelter and the consumption of contaminated plants were identified.

Overall, the assessment of the environmental hazard potentials adequately pointed to the identified environmental impacts. For example, the indicator for “paragenesis with heavy metals” points out the high environmental hazard potential of heavy metals from nickel mining, which corresponds to the high level of heavy metal particles detected in the surroundings of the Selebi-Phikwe mine. The presence of AMD at the mine site is correctly reflected by the high environmental hazard potential for “preconditions for AMD”. Moreover, the indicators “paragenesis with heavy metals” and “preconditions for AMD” indirectly point to the reported heavy metals, SO_2 and H_2S emissions from the smelter.

Furthermore, the lack of a mine closure plan and the non-rehabilitation of the mining site to this day are reflected in the mine closure indicator. The involved hazard potential is shown in the adverse effects under which the local population in the Selebi-Phikwe area still suffers. Similarly, the waste management indicator highlights a high hazard potential for the tailing damns near the mine and points to the negative impacts that the mine production already has had on the environment e.g. the contamination of water.

However, the site-related OekoRess methodology points towards a higher number of environmental hazard potentials than the amount of actual impacts identified. This includes a high environmental hazard potential for the indicator “use of auxiliary substances”, for which no impacts were identified.

Main findings of the governance analysis

Natural resources and their exploitation is a key element of Botswana’s economic development and wealth. Against this backdrop, the Botswanan government has set a focus on long-term sustainable development and the promotion of mining activities including favourable conditions for mining projects. The governance analysis has shown that Botswana’s mining sector is generally governed by a comprehensive legal and regulatory framework.

However, the enforcement of compliance with existing legislation is lacking. The implementation of the EIA Act is partially ineffective due to capacity shortages and inefficiencies of the responsible institution, the DEA. In addition, the case of BCL and the Selebi-Phikwe mine revealed weaknesses regarding the implementation of health and safety standards as well as environmental obligations. Accordingly, BCL did neither apply sufficient safety measures nor did BCL properly rehabilitate the mining site. This has caused deadly accidents as well as health and environmental damages such as contaminated water and the release of sulphur dioxide effecting the environment. The government is accused of failure to protect its citizens from these adverse effects and (by one source) for its plans to sell the Selebi-Phikwe mine without consultation.

Only limited sources and data were available regarding conflicts in the Selebi-Phikwe region. Conflicts primarily occurred around the closure of the Selebi-Phikwe mine and the resulting loss of jobs. Further triggers for conflict were the environmental impacts of the mining activities and accidents at the Selebi-Phikwe mine.

Do existing governance indicators reflect Botswana’s governance gaps and challenges?

Botswana’s overall average sector governance is well reflected in the set of Worldwide Governance Indicators (WGI). However, the weak implementation of mining and environmental legislation is not completely reflected.

Botswana has the highest value for WGI “Political Stability and Absence of Violence” (1.09 and a percentile rank of 90.00), which very well reflects the stable situation in the country and the absence of violence in the Selebi-Phikwe region. For “Control of Corruption” the country receives its second highest WGI score (0.93 and a percentile rank of 80.29). This somewhat corresponds with the governance in this area. However, the government is accused of close ties to the industry and a lack of transparency, which is not reflected in the high score.

Botswana has the lowest value for WGI “Voice and Accountability” (0.42) reflecting the average governance performance in this specific area. This could also explain the scarce information on opinions or public demonstrations around the Selebi-Phikwe mine conflicts and thus indicating limited freedom of expression and association.

Lastly, the country receives values between 0.51 and 0.53 for the three WGI indicators “Government Effectiveness”, “Regulatory Quality” and “Rule of Law”. This reflects well the governance effectiveness which can be located somewhere between well-developed e.g. as regards policy formulation and average governance performance e.g. regarding the implementation of safety and environmental standards at the Selebi-Phikwe mine.

An index that aims specifically at capturing a country’s performance regarding the protection of human health and of ecosystems is the Environment Performance Index (EPI). Botswana ranks 113 out of 118, scoring 51.70. Based on this case study and the available data, this indicator's value seems to reflect the average overall performance very well. The analysis showed a strong performance as regards sustainable development and environmental policies but weaknesses with regard to health impacts and contamination of water linked to the mining site.

As regards the overall governance, the Fraser Policy Perception Index (PPI) seems to adequately reflect the situation in the mining sector yet the value seems slightly too high. However, Botswana's policy attractiveness e.g. regarding its favourable investment conditions for explorations is well reflected in the Fraser PPI in which the country ranks 21 out of 91 with a percentile of 82.84. What is interesting is a significant decline of almost 9% from 2016 (rank 12 out of 104) to 2017, a year after the BCL mine was closed, possibly reflecting the struggle of the government to find a new investor and the high costs for environmental damage at the mine.

The Corruption Perception Index (CPI) rates countries on how corrupt their public sector is seen by experts. Botswana ranks 34 out of 180 countries assessed with a score of 61, which reflects the results of the governance analysis well, which showed that corruption was a point of criticism as regards the Selebi-Phikwe mine.

Conclusion

Overall, the assessment of the environmental hazard potentials adequately pointed to the identified environmental impacts. Furthermore, the existing indices and indicators show a good ability to reflect the specific governance situation in the mining sector of Botswana. Botswana's overall average sector governance is very well reflected in key governance indices of the WGI and even very well in the WGI Political Stability and Absence of Violence. However, as regards the Control of Corruption the WGI does not completely reflect the criticised closeness of the Government to the mining industry.

The PPI and the CPI also reflect the Botswana's sector governance well. The EPI even reflects very well the average governance situation. The case study once more underlines, that well-developed legislation does not guarantee its effective implementation. Botswana still needs stronger political will to enhance the implementation of health and safety as well as environmental standards in the mining sector, e.g. by putting a stronger focus on the penalisation of non-compliance.

Table 6-1: Overview on the governance indicators

Indicator	Botswana	Year	Indicator measures…	Applicability
Voice and Accountability (WGI)	0.42 (estimate between -2.5 and 2.5) 59.11 (percentile rank terms from 0 to 100, with higher values corresponding to better outcomes)	2016	Voice and Accountability captures perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.	Reflects well the average governance performance in this specific area in Botswana. +
Political Stability and Absence of Violence (WGI)	1.09 (estimate between -2.5 and 2.5) 90.00 (percentile rank terms from 0 to 100, with higher values corresponding to better outcomes)	2016	Political Stability and Absence of Violence/Terrorism measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism.	Reflects very well the overall governance and Botswana's political stability. The study found no evidence for violence or terrorism in the mining region. ++
Government Effectiveness (WGI)	0.51 (estimate between -2.5 and 2.5) 70.67 (percentile rank terms from 0 to 100, with higher values corresponding to better outcomes)	2016	Government Effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.	Reflects well the governance which can be located somewhere between well-developed e.g. as regards policy formulation and average e.g. regarding the implementation in the mining sector +
Regulatory Quality (WGI)	0.53 (estimate between -2.5 and 2.5) 70.19 (percentile rank terms from 0 to 100, with higher values corresponding to better outcomes)	2016	Regulatory Quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.	Reflects well the well-developed policy formulation in contrast to the weaknesses regarding the implementation of policies such as safety and environmental standards in the Selebi-Phikwe mine. +
Rule of Law (WGI)	0.52 (estimate between -2.5 and 2.5) 70.67 (percentile rank terms from 0 to 100, with higher values corresponding to better outcomes)	2016	Rule of Law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights,	Reflects the overall average to well-developed governance performance well. +

			the police, and the courts, as well as the likelihood of crime and violence.	
Control of Corruption (WGI)	0.93 (estimate between -2.5 and 2.5) 80.29 (percentile rank terms from 0 to 100, with higher values corresponding to better outcomes)	2016	Control of Corruption captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.	Reflects somewhat the governance in this area. However, the government is accused of close ties to the industry. -
Environmental Performance Index (EPI)	Rank 113 of 180, Score 51.70 (out of 100)	2018	The protection of human health and protection of ecosystems.	Reflects very well the overall average governance in the environmental sector. ++
Fraser Policy Perception Index	Rank 21 of 91, Score 82.84 (out of 100)	2017	The index measures the overall policy attractiveness and the country's government policy on attitudes towards exploration investment.	Reflects very well the mining sector's high policy attractiveness. Yet, the value seems too high to reflect the overall average governance in the mining sector.
	Rank 12 of 104, Score 91,79 (out of 100)	2016		It shows a decrease of almost 9% from 2016 to 2017, a year after the BCL mine was put under liquidation, in policy perception possibly reflecting the struggling of the Government to find a new investor and the high costs for environmental damage at the mine +
Corruption Perception Index (CPI)	61 (rank 34/180; scale 0 -100)	2017	Describes the perception of the corruption in the public sector by experts	Reflects well the governance in this area and the criticism of corruption as regards the Selebi-Phikwe mine. +

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