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OekoRess II: Country Case Study V

Vietnam: Tungsten Mining (Nui Phao Mine)

by

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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 environmental hazard potentials and the actual reported environmental impacts of the Nui Phao tungsten mine in Vietnam, which is one of the largest tungsten mines in the world. The mining operations have contributed to the pollution of soils and groundwater in the region, and have affected people's health through high noise and dust levels. A resettlement program and pollution have led to complaints by local communities. The site-related environmental hazard potentials, identified by the OekoRess methodology, were mostly confirmed by the analysis of the actual environmental impacts at the mining site. However, despite a high potential of conflict with the local government according to the respective OekoRess indicator, no violent conflicts have been reported at the site.

Existing governance indicators, in particular the Worldwide Governance Indicators, the Fraser Policy Perception Index and the Environmental Performance Index, adequately reflect the limited capacity of Vietnam's authorities to avoid negative environmental impacts at the Nui Phao mine. Although the mining sector is relatively well regulated, environmental damages like the contamination of soils and water bodies are common, which points to an implementation gap regarding existing policies. The governance indicators help detect and explain this gap.

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 führte 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.

In dieser Fallstudie werden die Umweltgefährdungspotenziale und die Umweltauswirkungen des Nui-Phao-Bergwerks in Vietnam, das eines der größten Wolframbergwerke der Welt ist. Der Bergbau hat zur Verschmutzung von Böden und des Grundwassers in der Region beigetragen und die Gesundheit der Menschen durch einen hohen Lärmpegel und hohe Staubwerte beeinträchtigt. Ein Umsiedlungsprogramm und die Umweltverschmutzung haben zu Beschwerden der lokalen Gemeinschaften ge-

führt. Die mit der OekoRess-Methodik identifizierten standortbezogenen Umweltgefährdungspotenziale wurden größtenteils durch die Analyse der tatsächlichen Umweltauswirkungen des Bergwerks bestätigt. Trotz eines hohen Konfliktpotenzials mit der lokalen Regierung nach dem jeweiligen ÖkoRess-Indikator wurden jedoch keine gewaltsamen Konflikte am Standort gemeldet.

Die bestehenden Governance-Indikatoren, insbesondere die Worldwide Governance Indicators, der Fraser Policy Perception Index und der Environmental Performance Index, spiegeln die begrenzte Fähigkeit der vietnamesischen Behörden wider, negative Umweltauswirkungen im Bergwerk Nui Phao zu vermeiden. Obwohl der Bergbau relativ gut reguliert ist, sind Umweltschäden wie die Verschmutzung von Böden und Gewässern weit verbreitet, was auf eine Umsetzungslücke bei den bestehenden Politiken und Regulierungen hindeutet. Die Governance-Indikatoren helfen, diese Lücke zu erkennen und zu erklären.

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List of Abbreviations

AMD	Acid Mine Drainage
APT	Ammonium Paratungstate
AZE	Alliance for zero extinction
CBA	Cost-benefit analysis
CDP	Community Development Plan
CPI	Corruption Perception Index
CSR	Cooperate Social Responsibility
dB	decibel
DONRE	Department of Geology and Minerals of Vietnam
DPSIR	Driving forces, pressures states, impacts and responses
EPI	Environmental Performance Index
GDP	Gross Domestic Product
GPI	Global Peace Index
ha	hectare
ICERD	UN Convention on the Elimination of All Forms of Racial Discrimination
ICMM	International Council on Mining and Metals
ICOLD	International Comission on Large Dams
km	kilometre
MONRE	Ministry of Natural Resources and Environment
NGO	Non-Governmental Organization
PAG	Potentially Acid Generating rocks
PCDP	Public Consultation and Information Disclosure Plan
REE	Rare Earth Elements
TSF	Tailings Storage Facility
US$	United States Dollar
USGS	United States Geological Survey
WGI	Worldwide Governance Indicators

1 Focus of the study and relevance

The following case study is the fifth 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 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 and governance contexts. In OekoRess I, a method to evaluate the ecological availability of raw materials and the site-related potential for environmental hazards posed by mining operations was developed with the aim to further developing 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 indicator 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 questions 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-related assessment approach developed as part of the OekoRess I project.

This case study analyses the environmental hazard potentials and the environmental impacts of the Nui Phao tungsten mine in Vietnam. The Nui Phao mine is one of the largest tungsten mines in the world and the mining project was the reason for one of the largest resettlement and compensation projects in Vietnam. The mining operation contributes to already existing pollution of soils and groundwater in the region, and impacts people's health through high noise and dust levels. The resettlement program and pollution have led to complaints of the local communities; however, no violent conflicts have been reported.

The case study is structured in four parts: First, the structure of the mining sector of Vietnam and its contribution to the national economy is analysed (chapter 2). Second, a brief overview of the Nui Phao 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 potential for environmental hazards posed by the mining operation are discussed using the OekoRess I methodology and selected environmental impacts and reactions to these are described using the DPSIR framework that was also used in the UmSoRess case studies (chapter 4).[4] Fourth, the governance of Vietnam's mining sector is analysed (chapter 5) and last, the findings of the assessment of the potentials for environmental hazards and environmental impacts and the governance analysis are compared to existing governance indicators and indices and first conclusions for the methodology development are drawn (chapter 6).

[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

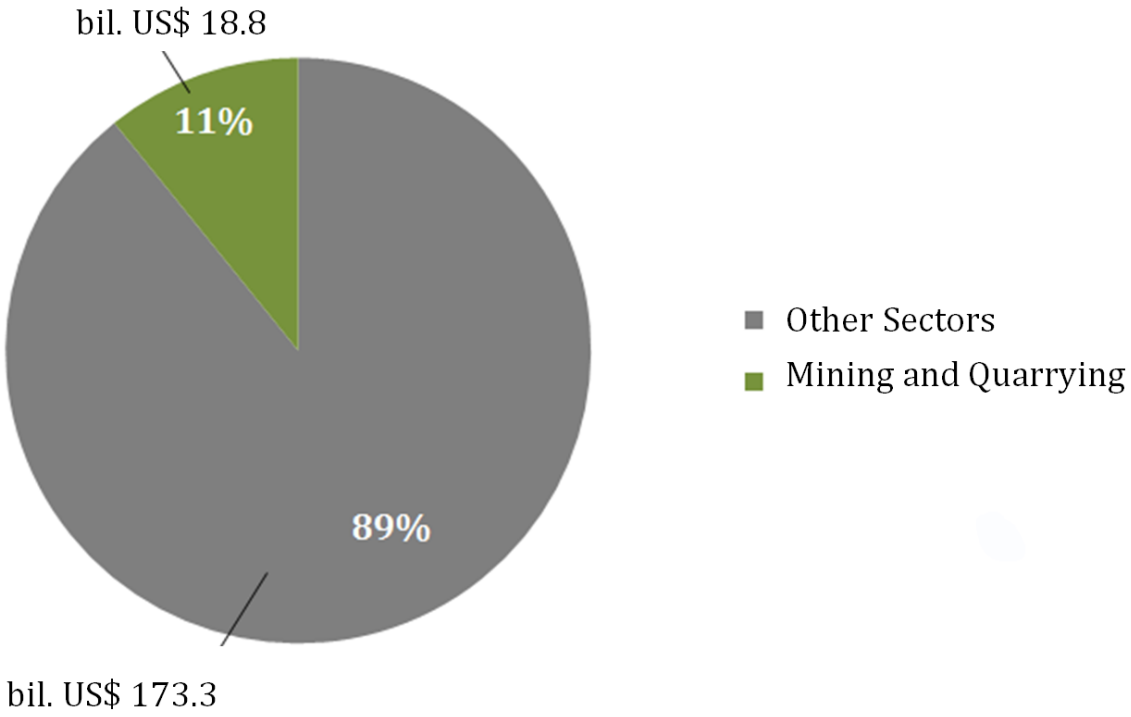
[3] The case studies and fact sheets on the standards and approaches analysed can be accessed here: https://www.umweltbundesamt.de/umweltfragen-umsoress

[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 Vietnam's mining sector

Since the Doi Moi political and economic policy reforms in 1986, Vietnam's economy and its mining sector developed and recorded large growth. Vietnam embarked on a path to a market-based economy with increased economic liberalisation and the production of more competitive and export-driven industries (Whitney 2013). Since that time and within a quarter of a century, Vietnam transformed from one of the poorest countries in the world to a global trading partner with a per capita income of around US $2,100 in 2015 (Whitney 2013; World Bank 2016a; World Bank 2016b).

Figure 2-1: Share of mining and quarrying to the GDP in 2014



Source: General Statistics Office of Vietnam (2017).

According to the General Statistics Office of Vietnam, in 2014, the mining and quarrying sector contributed 10.8 % to the country's total estimated gross domestic product (GDP) of US$ 173.3 billion[5] (see Figure 2-1). From 2010 to 2015, the total GDP has been growing constantly at very high rates, simultaneously the mining and quarrying sector also grew every year. The share of the sector's contribution to the GDP fluctuates between 9 and 11 % (compare Table 2-1). Accordingly, the sector has significant relevance for the Vietnamese economy.

Table 2-1: Development of Vietnam's GDP (calculated at basic prices from 2010)

	2010	2011	2012	2013	2014	2015 preliminary
Total GDP (Bil. US$)	94.9	122.3	142.8	157.7	173.3	184.5
Mining and quarrying (Bil. US$)	9.0	12.1	16.3	17.7	18.8	17.7
% of Total GDP	9.5	9.9	11.4	11.0	10.8	9.6

Source: General Statistics Office of Vietnam (2017).

[5] Exchange rate: 1 US$ = 22.727,25 VND

The mining and quarrying sector shows a high work productivity since it contributed almost 11 % to the GDP in 2014 while only employing 0.5 % of the country's workforce. Moreover, the work productivity in the sector is continuously increasing as the employment is going down while the value of produced goods increases (compare Table 2-1, Table 2-2). In 2014, the sector employed a total of 253,200 people (General Statistics Office of Vietnam 2017).

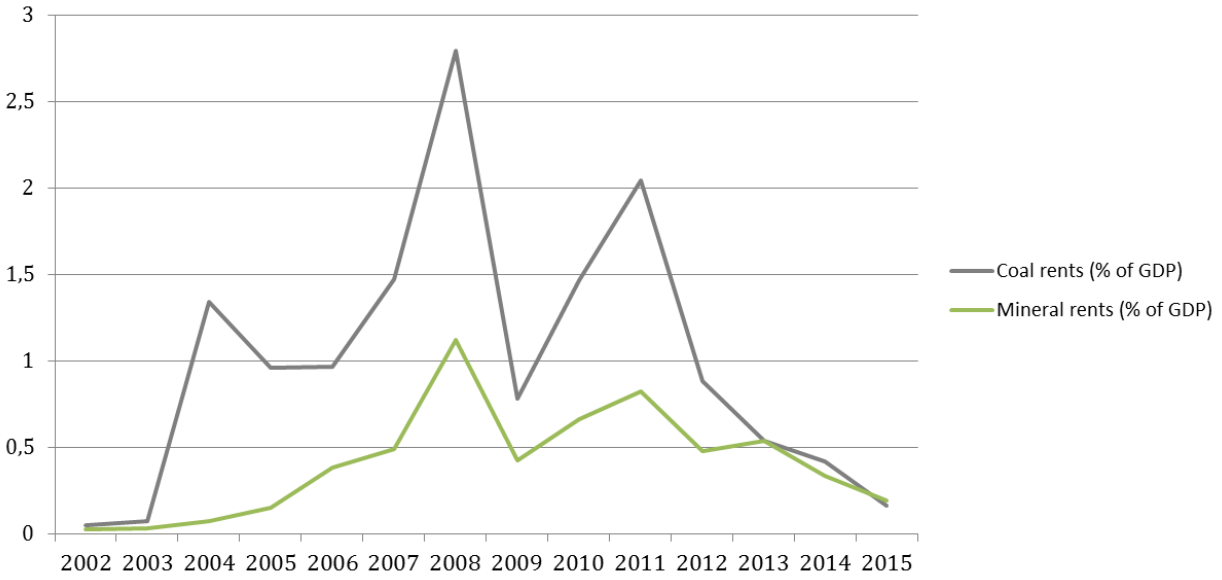
Table 2-2: Development of employment in the mining and quarrying sector

	2010	2011	2012	2013	2014	2015 preliminary
TOTAL (in thousands)	49,048.5	50,352.0	51,422.4	52,207.8	52,744.5	52,840.0
Mining and quarrying (in thousands)	275.6	279.1	285.5	267.6	253.2	237.6
% of total	0.6	0.6	0.6	0.5	0.5	0.5

Source: General Statistics Office of Vietnam (2017).

Both mineral and coal rents (% of GDP) showed a high variability during the last years: Percentages rose from 0.023 % (minerals) respectively 0.028 % (coal) in 2002 to 1.118 % (minerals) respectively 2.794 % (coal) in 2008, followed by a decline to 0.189 % (minerals) respectively 0.162 % (coal) in 2015 (World Bank 2017a; 2017b). Nevertheless, the metals and mining industry had a compound annual growth rate of 10.2 % between 2010 and 2014. The total revenues in 2014 added up to US$ 5,936.3 million. The iron and steel segment was the most lucrative accounting for 66.1 % of the metal and mining industry's total value in 2014. The coal segment accounted for another 27.1 % of the industry's value (Market Line 2016).

Figure 2-2: Development of mineral and coal rents as % of GDP in Vietnam



Source: Slightly modified after World Bank (2017a, 2017b).

The large instabilities and fluctuations between growth and decline in value will probably remain unchanged in the following years (Market Line 2016). At the current time, Vietnam produces fewer raw materials despite the rising demand for these products. One of the problems is the lack of foreign or domestic investors in Vietnam's mining sector, especially in the fields of exploration, production and processing. Therefore, public as well as private projects can only achieve little progress (Hundt 2014). However, this is only a development of the last years after the introduction of the 2010 Mineral law,

which led to an export ban of certain raw materials (see Chapter 5).

Since the introduction of the Doi Moi policy and the opening of the economy to foreign investment Vietnam's industry value has grown strongly (Market Line 2016) and the number of international companies investing in mining projects increased. Especially mining and production of materials like bauxite, cement, copper and gold have benefited from this investment. In 2012, investments in the mining and quarrying sector amounted to approximately US $2.6 billion, which represented about 6.9 % of the total investments in the country. In order to attract international interest in the country's potential for mining coal and non-fuel minerals, the Government of Vietnam pursued the creation and approval of decrees in support of the implementation of the 2010 Mineral Law during 2012 and 2013 (see chapter 5 on Governance). In addition, the government intends to secure more raw materials for the national heavy industry because exports of raw minerals are less profitable. Therefore, since 2012, the export of ore, raw marble and granite have been prohibited (Hundt 2014).

In Vietnam, there have been more than 5000 mineral occurrences identified with more than 60 kinds of minerals. Most of the principal reserves like iron, coal, manganese, chromate, nickel, zinc and copper are located in the north of the country (Mining Vietnam 2012). However, in contrast, Vietnam's Bauxite-Alumina and aluminium industry is distributed in the south, mainly in the Tay Nguyen provinces (accounting for 91.4 % of the country's reserves) (Mining Vietnam 2012).

The country produces a large variety of metals and minerals. Vietnam has a substantial share of world production for the metals bismuth (11.8 %), titanium (9.1 %) and tungsten (6.9 %) (compare Table 2-3).

Table 2-3: Mineral Production in Vietnam in 2014

Mineral [*= critical according to EC 2014]	Production 2014		
	Volume [t] (unless otherwise noted)	% of ∑ World	Rank
Antimony*	1,074	0.7 %	9
Baryte	100,000	1.0 %	12
Bauxite	1,090,000	0.4 %	17
Bismuth	400	11.8 %	4
Fluorite*	37,000	0.9 %	14
Kaolinite	650,000	2.6 %	9
Phosphate*	2,470,900	1.0 %	11
REE*	250	0.2 %	8
Titanium	1,100,100	9.1 %	4
Tungsten* *(estimate 2016 according to USGS)*	6,000	6.9 %	2
Tin	5,400	1.5 %	8

Source: BGS (2017), USGS (2017).

In the global context, the production of tungsten plays an important role. Until 2013, China has been

the largest producer, followed by Russia, Bolivia and Canada who have produced significantly smaller amounts (each between 2 to 3 % of global production). In 2013, Vietnam had its first year of operation at the Nui Phao mine and became the fourth largest producer of tungsten. Since then the country's share has been constantly increasing up to almost 7 % in 2016, becoming the second largest tungsten producer following China which supplies 82 % of world production (USGS 2014, 2015, 2016, 2017, compare Table 2-4).

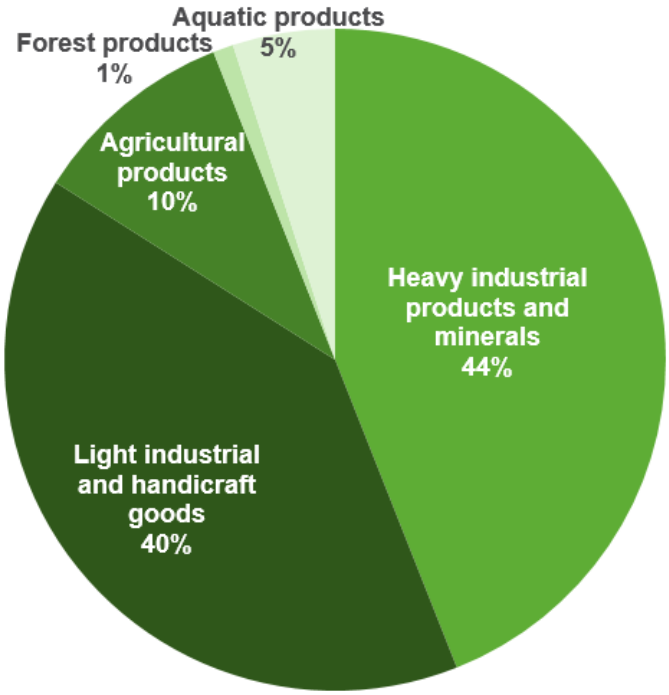
Table 2-4: Development of tungsten mine production in Vietnam

Year	2012	2013	2014	2015	2016 (estimate)
Production in tons	0	1,660	4,000	5,600	6,000
% of ∑ World	0	2.03	4.60	6.26	6.94
Rank	-	4	2	2	2

Source: USGS (2014, 2015, 2016, 2017).

In 2012, Vietnam's main trading partners were Australia, Burma, China, Germany, Hong Kong, India, Japan, the Republic of Korea, Malaysia, Taiwan, Thailand and the United States. The United States were Vietnam's leading export partner, followed by Japan and China. The total value of exports in 2014 was US$ 150.22 billion. The main commodity groups contributing to the value are heavy industrial products and minerals with 44% and light industrial and handicraft goods with 40 %. The other commodity groups together only supplied 16 % to the export value (compare Figure 2-3). The General Statistics Office of Vietnam does not specify the groups any further. However, data for the export value of coal and tin is published separately. The export value of tin and coal amount to US$ 49.400 million and US$ 7,266.100 million respectively (General Statistics Office of Vietnam 2017).

Figure 2-3: Share of the value of export of goods by commodity group in Vietnam in 2014



Source: General Statistics Office in Vietnam (2017).

In Vietnam, there are both small artisanal mines and large mining companies with several mines, containing many different minerals (Whitney 2013). There are also many illegal mining activities carried out, using very simple and often manual technologies (Hundt 2014).

The state-owned Vietnam Coal and Mineral Industries Corporation (Vinacomin) is the largest of the about 2,000 companies being active in Vietnam's mining sector. The company dominates the industry as major shareholder of mineral mining businesses. It resulted from the merger of the Vietnam Coal Corporation (Vinacoal) and the Vietnam Minerals Corporation (Vimico) and is active in the mining and processing of coal, non-ferrous and rare metals (Australian Trade and Investment Commission 2016; Market Line 2016; Whitney 2013). The company produced 43 million tons of coal overall in 2013 of which 11.6 million tons were used for export (Hundt 2014). It is one of three state-owned groups responsible for ensuring national energy security and is assigned to manage and exploit natural resources and minerals in Vietnam (Mining Vietnam 2012).

3 Overview of the Nui Phao mining operation and geology

The Vietnamese Nui Phao polymetallic mine is one of the largest tungsten mines in the world (White 2016; MASAN Group 2016). The operator of the mine, MASAN Resources, is a subsidiary of the MASAN Group, which is one of the largest companies in Vietnam. The conglomerate company is engaged in various industries and acquired a controlling interest in the Nui Phao mine in 2010 (White 2016).

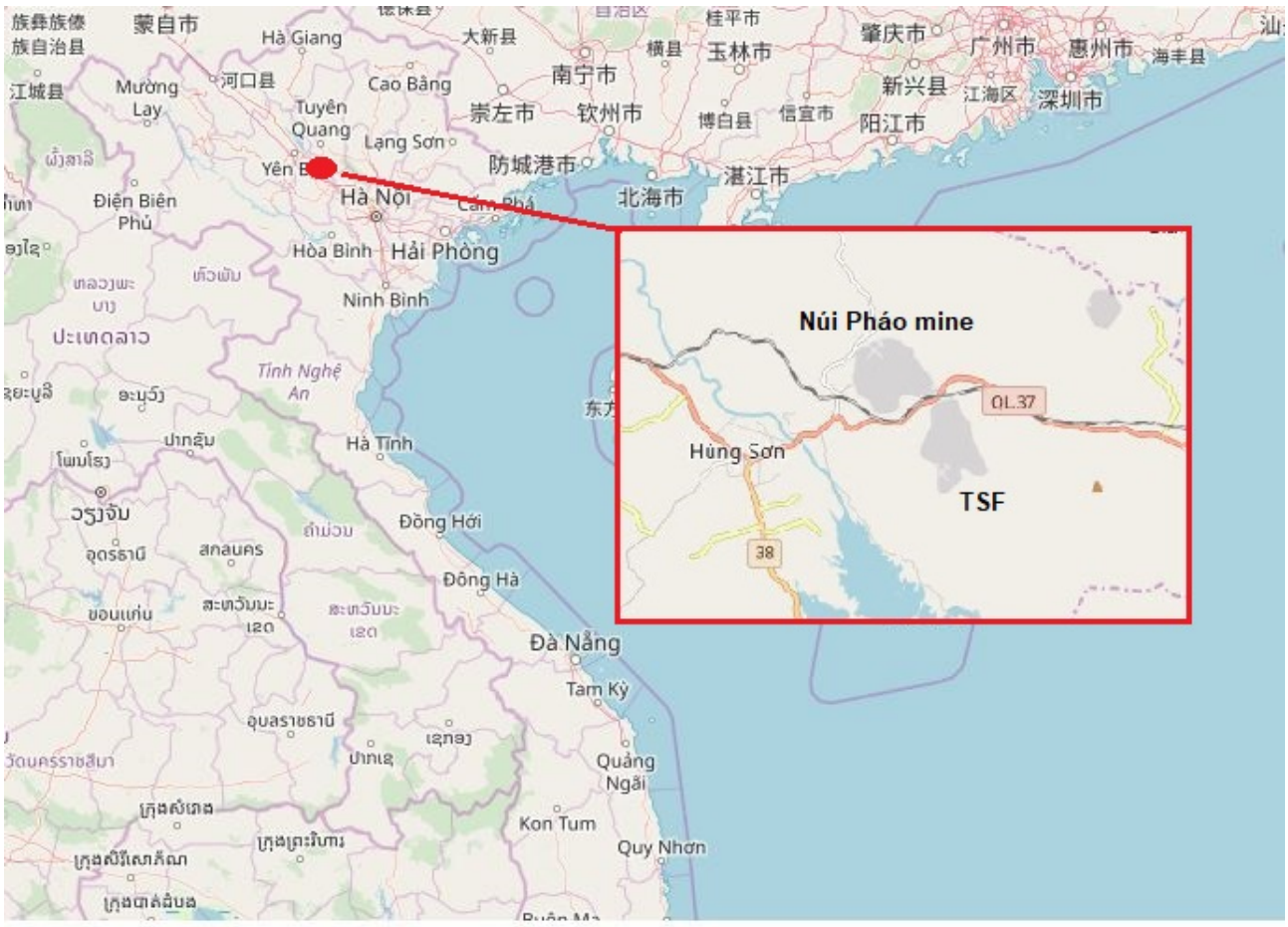
The deposit contains a rare combination of recoverable minerals, making it possible to jointly produce tungsten, bismuth, fluorspar and copper. The mine has been developed since 2004 and had its first year of full production in 2015 (USGS 2017; White 2016). In the same year, the company became the largest producer of tungsten outside of China (ITIA 2016).

3.1 Geography

The Nui Phao open-pit mine is located in the Thai Nguyen Province in northern Vietnam, approximately 80 km distant from Hanoi (Figure 3-1). Operated by the Nui Phao Mining Joint Venture Company, the property amounts to around 9.21 km^2 in a low mountain range characterized by elevations of up to 200m over sea-level and periodically changing drainage systems (Knight Piésold 2006b).

The surrounding landscape was shaped by mineral extraction activities, which becomes apparent on several disturbed areas, caused by former excavation and shaft mining (Knight Piésold 2006b).

Figure 3-1: Location of the Nui Phao mine



Source: OpenStreetMap (2019)

The Thai Nguyen Province is set in a tropical monsoon climate with two seasons and year-round high air humidity. From May to September, daily high temperatures averaging around 27°C to 29°C; in the cold season, from November to March, daily high temperatures are about 16°C to 20°C. While April and October are temperate months with variable weather, about 75 % of the annual precipitation takes place in the hot season (Knight Piésold 2006b).

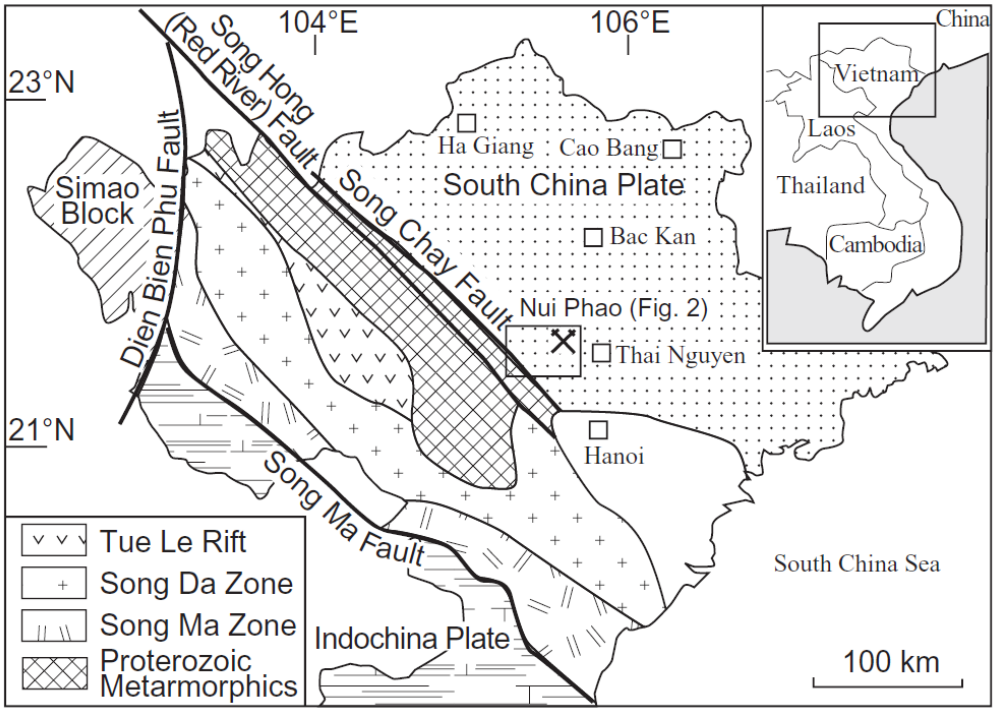
Vietnam is divided into 6 distinct ecological areas (eco-regions). Nui Phao is located in the "Northern Indochina Subtropical Moist Forests" eco-region, which is dominated by evergreen and semi-evergreen forests with multiple-layer canopies. This region represents an important habitat for a large number of species such as monkeys, snakes and big cats. Due to deforestation and other human activities in those forest ecosystems, the number of animal species declined rapidly (Worldatlas n.d.). In many cases, the historic cover of Tropical and Subtropical Broadleaf Forest has largely been shifted to agricultural crop cultivation, in spite of nutrient-poor soils in this region (Meyfroidt and Lambin 2009).

Main rivers near the project area are the Upper Thuy Tinh Stream, Bat Stream, Tin Valley, and Doi Ba Stream. All of them contribute to the flow in the Lower Thuy Tinh Stream, which is located downstream of the Nui Phao mine. Moreover, small rivers are usually auriferous in the wet season because of dominant monsoon patterns. Small villages and loosely spread housing estates are characteristic for the region. Most of the houses and industrial structures are supplied with electricity and water, nevertheless electric light is used sparsely by the residents (Knight Piésold 2006b).

3.2 Geological context and ore deposit formation

The deposit is located within the South China tectonic plate, which borders the Indochina plates. Accordingly, the region is characterized by several tectonic episodes of rifting and compression of the bordering plates (ITIA 2016) (compare Figure 3-2).

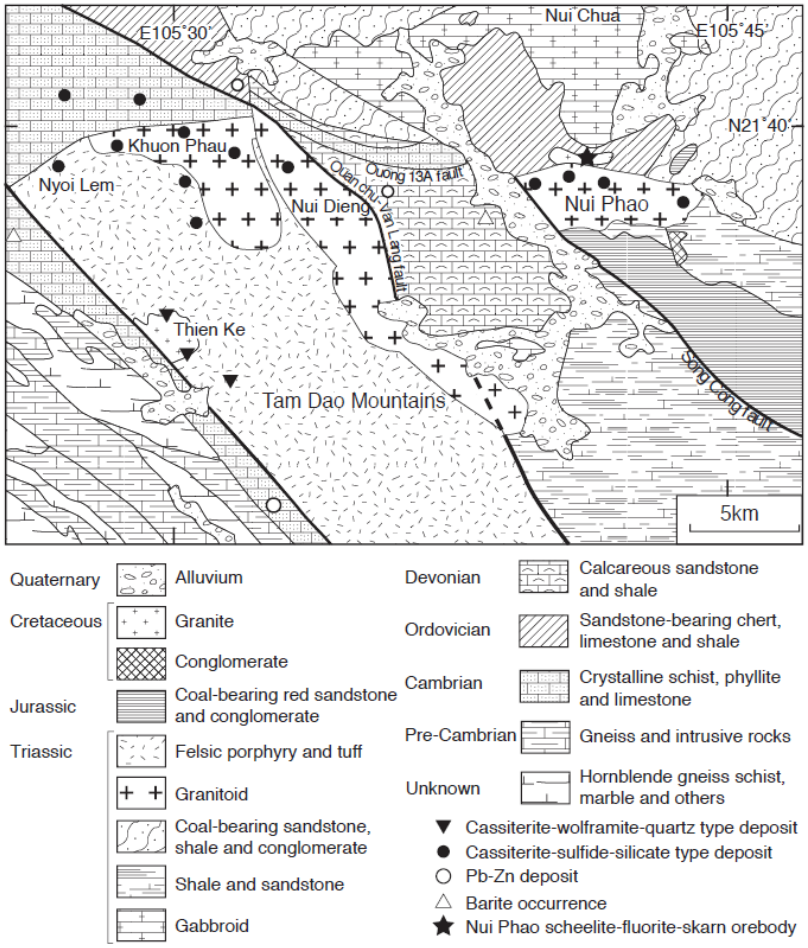
Figure 3-2: Locality map of the Nui Phao deposit in the South China Plate



Source: Sanematsu and Ishihara (2011).

The Ordovician-Silurian Phu Ngu Formation is widely distributed in the Tam Dao region where the Nui Phao mine is located (compare Figure 3-3). It consist of micaceous shale interlayered with sandstone, siltstone, silicified marble, dolomitic marble, and lenses of siliceous rock. Biotite Nui Phao has intruded this formation at Nui Phao. Sedimentary rocks that were altered and intruded in two episodes by granites underlie the Nui Paho deposit. The sedimentary rocks are called Phu Ngu and consist of calc-silicate meta-sediments.

Figure 3-3: General geology of the region



Source: Sanematsu and Ishihara (2011).

Present at the southern part of the project, the first intrusion of the Nui Phao biotite granite formed an intercalated assemblage of magnetite, garnet, pyroxene and amphibole-rich skarns, as well as granitic and pegmatitic dykes and sills. Exposed in the northern part of the deposit, the second intrusive event at the Da Lien granite resulted in greisenisation, massive pyrhotite-fluorite-albite overprinting and tungsten mineralization. The Da Lien mineralization is hosted in massive sulphide. The main ore deposit consists of polymetallic skarn and greisen related to intrusion. The mineralization is characterized by W-Au-Cu-Bi-F-Be-bearing minerals occurring within the two-mica biotite and muscovite granite (Knight Piésold 2006b, MASAN Resources 2017a)

3.3 Mining and Processing

The ore is mined in an open pit procedure with a relatively low strip ratio leading to very low operational costs (White 2016). The mine extracts four products: tungsten, fluorspar, bismuth and copper. This helps to stay profitable during periods of low prices for certain commodities (MASAN Resources 2017a).

The mine has a nominal size of 1,600 meters by 620 meters and a depth of 200 meters. The strip ratio is 1.5 to 1. Accordingly, 1.5 tons of waste is produced in order to access 1 ton of ore (MASAN Resources 2012). The mining operation is using an open cut method with 5 meter benches. 10 by 10 meter drilling is done to control the ore zone boundaries. Explosive charges are used for blasting to break up the ore. The ore is then transported to the processing facility. Waste is stored in a waste dump that is located 1.5 km from the open pit; chemically suitable waste is used for building up the tailings dam walls of the storage facility approximately 2.5 km from the mine.

The process plant has a capacity of processing 3.5 million tons of ore per annum and produces concentrates of copper, tungsten, fluorspar and bismuth. The ore is first crushed in a multistage process until the size is reduced to a relatively fine fraction. The fine ore is than stockpiled and transported to the grinding circuit where it is milled in a two stage process. Afterwards the fine milled ore is processed in a number of steps to extract the four products copper, tungsten, fluorspar and bismuth.

First the copper is extracted by separating copper sulphides (with flotation) from the milled ore. The copper concentrate is than thickened by flocculation and dewatered and finally packed into bags for shipping.

The milled ore separated from the copper sulphides is then going through a bulk sulphide flotation process which separates sulphide minerals that contain iron and bismuth, from the oxide minerals, that contain tungsten and fluorite.

The tungsten is recovered in a gravity circuit, dewatered, dried and transported to the Joint Venture facility where the concentrate is converted to a high grade Ammonium Paratungstate (APT) which is the final product. The rest of the oxide mineral concentrate is going through another flotation process to produce a Fluorite concentrate which is ready for shipping.

Sulphide minerals from the bulk sulphide flotation are again going through a flotation circuit to separate bismuth rich minerals, which are thickened by flocculation, dewatered and dried. Part of it is bagged and sold as concentrate, the rest is further processed: The dried concentrate is leached with salt and sulphuric acid. The leached concentrate is cemented and bagged for sale (ITIA 2016; MASAN Resources 2016).

The waste from the processing is stored in a tailings storage facility (TSF). The waste from the sulphide mineral processing and the oxide processing waste are stored separately in the TSF. The TSF is designed in accordance with standards set by the International Commission on Large Dams (ICOLD) (ITIA 2016).

The mine is well connected to roads and rail that are linked to the closest ports of Hai Phong and Quang Ninh from which the products are transported to international markets. The ports are located in the town Ha Long that is about 200 km southeast of the mine. Equipment and materials necessary for operating the projects are also received from here (MASAN Resources 2017a). The products are sold to international markets; Europe with almost half of all sales is the most important customer.

Table 3-1: Sales of Nui Phao Mine to region

Year	Sales in %
EU	46
Japan	9
Middle East	2
US + Canada	12
Vietnam	18
Other	14

Source of Information: MASAN Resources (2017a).

The mine has estimated proven and probable ore reserves of around 66 million tons leading to an expected life of mine of approximately 20 years. The resources amount to 88 million tons (MASAN Resources 2017a; ITIA 2016).

In 2016, MASAN resources increased their ore output by 3 % and extracted 3,754,000 tons of ore (compare Table 3-1). The processing productivity was increased significantly by 24 % leading to a production of 6,357 tons of tungsten concentrate in 2016 (compare Table 3-2). In 2016, the mining operation employed a total of 1,027 direct employees while 600 employees are working for a contractor (MASAN Resources 2017a).

Table 3-2: Production data in 2015 and 2016

Production	Unit	2015	2016
Ore mined	kt	3,543	3,654
Ore processed	kt	3,229	3,642
Tungsten concentrate (contained)	t	5,123	6,357
Tungsten equivalent units (contained)	t	10,250	12,926

Source of Information: MASAN Resources (2017a).

The construction of the mine included the compensation and resettlement of seven communities and 1,925 households. After taking over the project, MASAN Resources committed to continue engaging in previously made agreements. According to MASAN the main objectives were to minimize impacts of land acquisitions, maintain or improve the economic standards of affected people and sharing the benefits of the project with the communities. The company built three resettlement sites making it one of the largest resettlement projects in Vietnam (CSR Asia 2016; White 2016; see chapter 5.2 for further information).

4 Overview of environmental hazard potentials and environmental 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 Nui Phao mine, which are described in detail below.

The assessment of the EHPs of the Nui Phao 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	Potential for environmental hazards		
		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, earthquake, storms, landslides		X	
	Water Stress Index (WSI) and desert areas			X

Thematic Cluster	Indicator	Potential for environmental hazards		
		low	medium	high
	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)

As described in the Geology section, the ore is hosted in massive sulphide; accordingly, all necessary elements to form AMD are present. Moreover, historic mine waste produced by artisanal miners in the direct vicinity of the project is visibly contributing to the formation of AMD. Surface waters in the downstream areas are already affected by low pH and high conductivity. The composition of the ore and the fact that historically triggered AMD is present lead to a high potential for environmental hazards (Knight Piésold 2006b) (*High potential for environmental hazards).*

Paragenesis with heavy metals

According to a study commissioned by the former owner of the mine, the region is well known for elevated levels of arsenic and heavy metals in the soil (Knight Piésold 2006b). However, this contamination is generally not connected to the geochemistry of the ores produced and to current mining processes, but probably associated with natural weathering over geological time of arsenic bearing host rock (Knight Piésold 2006b). The soils in direct vicinity of the mine show elevated levels of arsenic, lead and boron. Although the contamination is mainly not traced back to current mining activities, heavy metals are present, and accordingly the movement of rock and soil during the mining project can lead to a further distribution of the toxic material. Therefore the potential for environmental hazards caused by heavy metals is high (*High potential for environmental hazards*).

Paragenesis with radioactive components

According to a presentation of MASAN Resources from 2011, the deposit has a low radioactivity. However, this evaluation is not specified any further (MASAN Resources 2011). Due to this lack of information and based on the measurement instructions the potential for environmental hazards caused by radioactivity is estimated to be medium (*Medium potential for environmental hazards*).

Deposit size

The grade for Tungsten refers to WO_3 equivalents. Accordingly, the deposit contains a total of 118.000 tons of WO_3 equivalents making it a large deposit. Therefore, the size of the deposit poses a high potential for environmental hazards. (*High potential for environmental hazards*)

Specific ore grade

The Nui Phao deposit can be characterized as a greisen type. The average ore grade of such deposits is within the range of 0.1 and 0.3 %WO_3 (ITIA 2012).

The deposit has an average grade of 0.18 WO_3 (MASAN Resources 2012) and is therefore considered as average for this type of deposit. Accordingly, the ore grade poses a medium environmental hazard potential (*Medium potential for environmental hazards*).

4.1.2 Technology

Mine type

The Nui Phao deposit is exploited in a hard rock open pit (cf. Section 3.3). Open pit mining disturbs the surface to a much larger extent than underground mining. The disturbance only extents to the size of the ore body. In consequence, the applied mining method poses a medium potential for environmental hazards. (*Medium potential for environmental hazards*)

Use of auxiliary substances

Nui Phao produces four different concentrates which need to be separated from the waste material. Accordingly, a number of processing steps need to be carried out before the concentrates are ready for shipping. Various floatation steps with the use of flocculation reagents are performed; moreover leaching steps involve the use of sulfuric acid (cf. Section 3.3). Overall the ore processing involves the usage of a variety of toxic reagents which pose a high potential for environmental hazards (*High potential for environmental hazards*).

Mining waste

Waste generated in the mining process is mainly dumped and partly used as construction material for the tailings storage facility. Waste from the processing is dumped as slurry in the tailings storage facilities in two separate streams, one for the sulphide and one for the oxide residues (ITIA 2016). The tailings storage facility is a large dam as defined by ICOLD (International Comission on Large Dams) because some of the wall structures exceed the height of 15 meters (cf. Section 3.3). Accordingly, the waste material management poses a high potential for environmental hazards (*High potential for environmental hazards*).

Remediation measures

According to the Sustainability Report 2015 (MASAN Resources 2015), the company is implementing rehabilitation measures in parallel with the operation until mine closure. E.g. the company is planting trees as a barrier for dust emissions and for noise reduction. Also local grass seeds are collected to later rehabilitate the waste dumps. Since the plan foresees rehabilitation in parallel with the operation the potential for environmental hazards caused by an insufficient mine closure management is low (MASAN Resources 2017a). (*Low potential for environmental hazards*)

4.1.3 Site (surroundings)

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

The environmental hazard potential due to natural accidents is assessed by analysing four individual sub-indicators:

The risk for earthquakes is low:

- The risk for floods is low; no floods have been reported in the last 100 years.
- The mine is located ca. 200 kilometres from the coast with top wind speeds in a range of 154 to 208 km/h in the last 100 years. Therefore the risk for tropical storms is medium.
- The risk for landslides is low.

The evaluation is carried out in accordance with the measurement 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.

The evaluation shows that a risk for tropical storms exists, which leads to an overall medium potential for environmental hazards caused by natural disasters (*Medium potential for environmental hazards*).

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) showing that Nui Phao is located in a region with increased water stress. Accordingly the potential for environmental hazards caused by water stress is high. (*High potential for environmental hazards*)

Protected areas and Alliance for Zero Extinction (AZE) sites

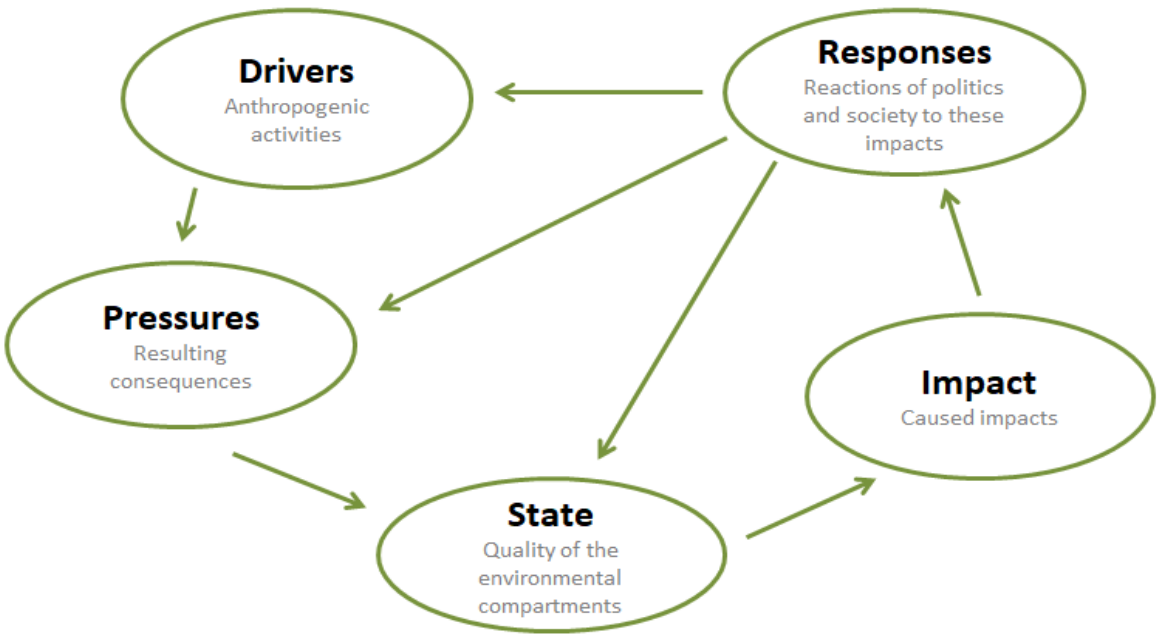
Georeferenced data for designated protected areas are used to assess hazards posed by mining extraction. The metric to evaluate EHPs corresponds to the method first described in the draft standard of the Initiative for Responsible Mining Assurance (IRMA 2014). The mine is not located within protected or highly protected areas or at "Alliance for Zero Extinction" sites. Accordingly the potential for environmental hazards for protected areas caused by the operation is low. (*Low potential for environmental hazards*)

Conflict potential with local population

The sub-indicators „Voice and Accountability" and „Control of Corruption" are very low having a percentile rank of 10.84 and 39.42 respectively (World Bank 2017c). This indicates that there are high risks with respect to insufficient involvement of local population groups and compliance of industry standards could be affected by corruption. Therefore, the EHP resulting from conflict potential with local population is high. (*High potential for environmental hazards*)

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 mainly focuses on mining operation's impact on soils and waterbodies and on the noise and dust emissions to the surrounding areas. Furthermore, it covers the impacts on health and livelihoods of the local population and points out responses of the mining company.

4.2.1 Pressures

The major environmental pressures of the Nui Phao mining operation are the contamination of soils and water bodies with arsenic, heavy metals and cyanide[7], the use of land and the emission of noise and dust. However, the natural occurrence of arsenic and heavy metals in waters and soils due to the climatic and geological setting, intensified by decades of (illegal) mining activities in the area, make the current and direct impacts of the mine hard to assess. Nevertheless, based on a comprehensive assessment of the initial situation of the project area (Knight Piésold 2006b), an ongoing monitoring program (MASAN Resources 2015; 2016; 2017a, b) and local press reports some statements about the environmental impacts of current mining activities and the company's responses can be made. The major environmental impacts of the operation and responses will be outlined in the following paragraphs.

4.2.2 State and Impacts

Land use and Biodiversity

Open-pit mining has considerable impacts on the ecosystems and landscapes of the region, as mining activities transform the entire landscape. The Nui Phao mine is located in an area that has been strongly affected by the economic growth of Vietnam since the 1990s: Most of the natural vegetation had been cleared in the past and transformed to densely settled rural areas, cultivated areas or mining sites. The population density of 283 inhabitants per km² is higher than the national average. The historic cover of tropical and subtropical forests has been displaced by early secondary growth, secondary forestry plantations and agricultural area. Likewise, the direct project area was under usage before the establishment of the mine and most parts of the environment were already converted to agriculture, settlements or artisanal mines. There were no threatened or endangered plant species identified in the project area of the Nui Phao mine before the mine operation started (Knight Piésold 2006b). The total area of the Nui Phao mining project is 335 ha; of which 91 ha are the open pit operations cover 91 ha and the, the polishing pond and tailing facilities cover 111 ha. Another 95 ha are used as different types of waste rock deposits, 20 more ha for the plant site. The fresh water reservoir extends to 10 ha and the low grade ore stockpile to 8 ha (Knight Piésold 2006b).

Contamination of soils and water bodies

One major environmental issue in the surroundings of the Nui Phao mine is the contaminations of soils

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

[7] According to the company's Environmental and Social Action Plan, a minor amount of cyanide is used in the process (Knight Piésold 2006a).

and water bodies with arsenic, heavy metals and cyanide. With regard to surface waters, this is particularly the case for the Cat River and the Thuy Tinh River. Nonetheless, the direct impact of mining activities at the Nui Phao mine is hard to ascertain for two reasons:

First, several studies indicate that high metal contents of soils and parent rocks have already been present in the area a long time before the mine began its commercial operation (Knight Piésold 2006b; Ngoc et al. 2009; Bass et al. 2010; Bui et al. 2016). This is due to the area's geological and geographical setting, as the elements naturally occur in the region (Ngoc et al. 2009).

Second, there is no literature available showing the quantitative results of investigations of emissions of the mining activities regarding heavy metals. Indeed, the mine operator published extended baseline-information on the environmental conditions during the planning phase in 2006, however, there is no such detailed information available for the current status. Furthermore, the Nui Phao mine cannot be accounted as being the only mine contaminating soils and water bodies in the area, as there is very high mining activity all over northern Vietnam and especially in the surroundings of the Nui Phao mine. Therefore, the entire region experiences elevated metal contents in soils and water bodies.

To sum up, it seems most likely that the high metal contents originate from a combination of both natural and anthropogenic sources (Knight Piésold 2006b; Ngoc et al. 2009; Bass et al. 2010; Bui et al. 2016).

Moreover, the interplay between natural sources and anthropogenic (mining) activities result in a mobilization of former inactive metals in the ground: In the humid climate of northern Vietnam, rain water solutes the sulphur from acid generating rock deposits from recent and historic mining, which would be rather inactive without the anthropogenic movement and fragmentation. For instance, in the surroundings of Nui Phao, 570,000 $m^3$of historic tailing material has been identified. This poses a significant source of sulphur, which produces acid solutions when it is exposed to the surface. Finally, this process results in low pH values in the rivers, which again mobilize heavy metals from the ground. As a result, these factors lead to a self-reinforcing process, where ecosystems and human health are significantly at risk (Knight Piésold 2006b; see sections on health).

In addition to that, the production line and the tailing facilities demand considerable amounts of water to operate. Especially the sulphur-rich tailings need enormous quantities of water to keep the potentially acid generating rock depositions permanently inundated. Although most part of the water is recycled, a sewage plant is necessary to clean run-off water (MASAN Resources 2015).

Even though there is no scientifically substantiated data available, local press reports numerous complains of people living in the neighbouring community. According to these reports, there are hints that the Nui Phao mine caused elevated levels of cyanide and arsenic in the environment. It was suspected that untreated wastewater bypassed the purification pond and drained into the rivers directly (Xay Dung 2017; VietNamNet 2017). In 2016, the local environmental office announced an inspection of 45 days for the Nui Phao mine (Nguyen 2016). The results of this investigation are not available, however VietnamNet (2017) reported the mine operator was fined for violating environmental regulations.

Air pollution and noise

Due to the reduced vegetation cover, traffic, constructions and mining activities, the background load of particles in the air is high and exceeds the regulatory requirements in Vietnam in the dry season. Especially due to the elevated arsenic content of the soils, the dust in that area is considered as a thread for human health (Knight Piésold 2006b). Noise pollution shows similar patterns: According to the high population density, traffic and manifold economic activities, the level of background noise is high and remains above 50 dB even during night time. (Knight Piésold 2006b).

The numerous activities connected to the Nui Phao mine, such as ground moving and construction activities, blasting and traffic are additional and significant sources of dust, noise and smell. There is no quantitative data available, however, there are complains about smell and noise from local people appearing in the newspapers (e.g. Xay Dung 2017).

Health and livelihoods of the local population

The documented elevated concentrations of arsenic, lead, and boron, which are naturally present in the area of the mine, reach levels that could pose health risks to local residents (Knight Piésold 2006b). Besides this, additional contaminations with heavy metals from current and past mining activities are present. The permanent exposure to these heavy metals from intake through different pathways (dust, drinking water, food chain) show significant impacts on the health of the people living close to the mining area. For example, high arsenic concentrations have been found in the bodies of tested volunteers (Knight Piésold 2006b; Ngoc et al. 2009). However, there was no information available on the specific health impacts on the people affected by the high concentrations of heavy metals.

Regarding livelihoods, agriculture is an important base for over 80 % of the people living in the area around the mine site. Main products are rice and tea, but also cassava, corn and fruits. Due to mining activities, the Phuc Linh community in the direct neighbourhood of the mining project is affected by a loss of agricultural productivity. Subsequently, some people changed their livelihood from agriculture to brick production (Knight Piésold 2006b).

4.2.3 Responses

Commitment to international standards

The Nui Phao mine and MASAN's environmental and social plans have been developed in accordance with IMF Performance Standards and with Equator Principles in order to "add value to our [the surrounding] communities and to minimize any adverse impacts on them from our project works" (MASAN Resources 2015: 27). According to MASAN, all parts of the operation have to comply with the Vietnamese regulatory requirements, the World Bank guidelines on social and environmental safeguards, and the ICMM Sustainable Development Framework (MASAN Resources 2015). The company defines yearly sustainability targets in the categories "people", "health and safety", "environment" and "community" and monitors its performance on reaching these targets (MASAN Resources 2015).

Rehabilitation

Due to the young age of the mine, there were no disclosure or landscape rehabilitation measures implemented yet. However, MASAN claims that a rehabilitation and mine closure plan is in progress (MASAN Resources 2015). Nevertheless, the actual scheduling of mine rehabilitation depends on the lifetime of the mine. MASAN builds up financial reserves for mine dismantling and rehabilitation. Until now, the budget for this accounts for almost 21 billion VND (roughly 950,000 US$; MASAN Resources 2017b).

Water and tailings management

Due to rising concerns of local communities, the company increased its expenditures to address environmental issues, particularly for building wastewater treatment plants and for improving its environmental audit and management program (MASAN Resources 2015). Heavy metals originating from pro-

cessing of the minerals are precipitated, thickened and stored within the tailings storage facility (MASAN Resources 2016). The company's water use is monitored and MASAN tries to reduce the extraction of water from the rivers around the mining area. The total water use of the mining operation peaked in 2015 and decreased in 2016 (MASAN Resources 2015; 2017b) due to a reduction in water use by optimizing the sulphuric and oxidic tailing facilities. Furthermore, the reuse of water had been increased in 2016. After being faced with complaints about the company's effluents and waste, the wastewater treatment ponds are now fully operable since 2016 and the company states that its discharge effluents meet the legislative requirements (MASAN Resources 2015). Water management was set as a priority for the next years (MASAN Resources 2015).

Nevertheless, as stated above, due to complaints of the local inhabitants in 2016, the environmental office announced an inspection of 45 days in Nui Phao mine. Nguyen (2016) and VietNamNet (2017) reported that the mine operator was fined for violating environmental regulations.

Noise and dust

One of MASAN's main objectives in 2015 was to establish systems to manage risks related to noise and dust. The company conducts quarterly monitoring of potential health risks like noise, dust and air pollution and takes measures when results are poor (MASAN Resources 2015). However, measures taken to reduce noise and air pollution are not listed in the company reports.

Health

The safety strategy of the mine operator appears to be successful as there were no records of severe accidents or employees suffered a lost-time injury in 2016. Besides an extensive safety training program, the employees have received training courses in first aid, fatigue management as well as hearing and lung awareness training (MASAN Resources 2017b).

Stakeholder engagement, grievance mechanisms and community development

The company reports that it has engaged in an ongoing dialogue with all the key stakeholders and that it has collected the different stakeholder groups' expectations (MASAN Resources 2015). MASAN adopted a complaints and grievance mechanism and received 84 complaints about environmental impacts (such as on water and noise pollution) in 2015, of which 5 could not be solved (in comparison, the company received 286 complaints about environmental impacts in 2014, of which all were solved) (MASAN Resources 2015).

MASAN has a community development program which focuses on the economic development of the surrounding areas. The company puts a focus on infrastructure, capacity building and agricultural extension services and tries to develop public private partnerships (MASAN Resources 2015; 2017b). One key activity of community development is employment of local people at the mining side itself and placing contracts with local enterprises. Almost three-quarters of all employees of the mine originate from Thai Nguyen Province (MASAN Resources 2017b).

5 Governance

5.1 Sector governance, regulation and effectiveness

The mineral policy of Vietnam was initially developed together with the Doi Moi political and economic policy reforms in 1986 (Whitney 2013). Since 1996, Vietnam has mining regulations in place, which were replaced in 2010. However, especially the new regulations are very complex and in many cases not clearly defined which sometimes hinders mining activities and external investments (Hundt 2014). Furthermore, the Mineral Law of 2010 (in the following the Mineral Law) neglects to define measures for environmental protection in mining, but refers to the Vietnam Environmental Law. Overall, Vietnam's governance is characterised by sound regulations and strategies, but a lack of coherence between them, and a lack of cooperation between the ministries in charge. Furthermore, the country struggles to balance commercial and sustainable development, and its political system with close relationships between politics and economy provides a breeding ground for corruption.

Institutional and administrative framework

Since 2002, the Ministry of Natural Resources and Environment (MONRE) is responsible for management of the mining sector and the export of minerals, controlling and revoking mining licenses with regard to location, duration, processing, production, safety and environmental protection. For each province, a respective Department of Geology and Minerals of Vietnam (DONRE) is in charge of the management of geology and mineral resources, which includes basic geological surveys, basic mineral resources surveys, mineral activities, protection of mineral resources, assessment of mineral resources potential and the discovery of mineral deposits (Mining Vietnam 2012; Whitney 2013)

Legal and regulatory framework

Vietnam's mining sector is mainly regulated by the Mineral Law of 2010, which replaced the 1996 Mineral Law and its amendment of 2005. The Mineral Law comprises the protection of unexploited minerals, the regulation of geological surveys and the management of mineral activities (Whitney 2013). It regulates mineral exploration and mining on the mainland, islands, internal waters, sea territories, the contiguous zone, exclusive economic zone and continental shelf of Vietnam (Fong-Sam 2012; Fong-Sam 2014). With the Mineral Law, the Government also encourages the development of a mineral strategy and national and regional mineral master plans in order to "promote sustainable development and ensure that mined products are used in a cost-effective and efficient way" (Mayer-Brown JSM 2011). The Mineral Strategy, a strategy for a 10-year period with a 20-year vision, covers strategical considerations on geological surveys, exploration, extraction, processing and the use of minerals. (Mayer-Brown JSM 2012).

The new mining law and the mineral strategy introduced several changes to the management of mineral resources, with some of the new regulations being very complex and not clearly defined, which hindered (foreign) mining activities and investments (Hundt 2014). One of the major changes in the legislation was the expansion of the legislation's scope: from covering only mineral and mining activities to exploration, extraction and mineral processing (Mayer-Brown JSM 2011). Along with these changes, investment projects in exploration and mining need to be accompanied by processing, with the aim to develop the local industry and create a higher socio-economic value. At the same time, export of raw and unprocessed minerals and ores was banned (e.g. for titanium ore, iron ore, copper ore, zinc ore, but also unprocessed marble and granite), unless domestic needs are met (Mayer-Brown JSM 2012; Hundt 2014; Australian Trade and Investment Commission 2016; Fong-Sam 2014; Tu Anh 2013). Since 2013, there is a list of minerals, including metallic and industrial minerals, which are allowed to be exported based on their respective export conditions, set by the Ministry of Industry and

Trade (Fong-Sam 2014; Fong-Sam 2016). These minerals are barite powder, bismuth, products processed from bauxite ores and titanium ores, copper and wolframite, fluoride, white marble, nickel ore and total rare-earth-oxide powder (Fong-Sam 2014). The export of rare earths must be approved by the Prime Minister (Mondaq 2012). These developments were (at least partly) responsible for decreasing (foreign) mining investments (Hundt 2014).

The explicit focus on socio-economic development finds also its expression in the overarching aim of the new legislation: The Mineral Law of 1996 was a mining policy for rational, economic and efficient management of mineral resources - also with regard to environmental issues. The 2010 Mineral Law articulates mineral development with no particular reference to environmental protection, but with a scope of promoting "sustainable socio-economic development, national defence and security, ensuring that minerals are protected, mined and used reasonably and in a cost effective and efficient way" (Mayer-Brown JSM 2011; Whitney 2013). Article 30 of the Mineral Law obliges mine operators to use equipment and materials to minimise impacts on the environment in order to "prevent and mitigate adverse impacts on, and upgrade and restore the environment according to law" (Socialist Republic of Vietnam 2010), but it does not define in a clear and detailed way how to reduce environmental pollution caused by mining activities, and which specific parts of further laws apply with regard to mining operations (Whitney 2013). Despite these imprecisions, applicants for mining licenses must have an environmental impact assessment report that refers to Vietnam's regulation on environmental protection in order to provide a forecast on the environmental impacts and on measures to protect the environment. For this, the applicants also have to consult the people's committee at the commune level (Schiappacasse et al. 2019).

Environmental legislation in the mining sector

Until the 1980s, no environmental legislation existed in Vietnam. Environmental policies were established over time, yet their enforcement still remains deficient (Whitney 2013). Vietnam has legislation in place, mainly in the form of the Law on Environmental Protection of 2014. It replaced the Law on Environmental Protection of 2005. Furthermore, several more specific laws are in force, like the Law on Water Resources of 2012 or the Law on Biodiversity of 2009.

The Law on Environmental Protection of 2014 "provides statutory provisions on environmental protection activities; measures and resources used for the purpose of environmental protection; rights, powers, duties and obligations of regulatory bodies, agencies, organizations, households and individuals who are tasked with the environmental protection task" (FAO 2014). With this law, the prevention of environmental pollution and degradation was set as a key aim of environmental protection. Furthermore, environmental protection should go "hand in hand with regional and global environmental protection", and must "not be detrimental to the national sovereignty and security" (Vietnam law and legal forum 2015).

Overall, the legislative system on environmental protection is referred to as being "relatively good", "comprehensive" and "sound" (Bass et al. 2010; IUCN 2016; Schirmbeck 2017). However, many conclude that implementation of the laws is weak (Bass et al. 2010; IUCN 2016; Schirmbeck 2017). Ortmann (2017: 2) concludes that the country has so far "been almost completely helpless in enforcing its own regulations and holding polluters and other environmental offenders to account". This has several reasons, mainly challenges regarding the coherence of policies, coordination and capacity (Bass et al. 2010; Schirmbeck 2017). With regard to mining issues, contradictions and a lack of coherence exist for example between the Law on Water Resources, the Law on Environmental Protection and the Mineral Law of Vietnam (Whitney 2013). Furthermore, as already stated above, the environmental laws are often vague, for example the Law on Environmental Protection repeatedly referring to a great number of other laws while not defining any measures to take.

In addition, cooperation and communication between the different political actors who issue and implement the laws is weak, and there is competition between responsible ministries (IUCN 2016; Schirmbeck 2017). Furthermore, non-compliance with legislation is hardly ever sanctioned, because of a lack of human and financial capacity, inadequate rule of law and corruption (Schirmbeck 2017). Furthermore, Vietnam's political system is characterized by a close relationship between the industry and the government, particularly because many companies are state-owned or formerly state owned. These close relationships provide a breeding ground for corruption. Based on these constraints, a "complaints-based system" evolved over time, where the state (only) responds to violations of environmental laws, when there is significant public pressure (IUCN 2016).

Illegal mining and corruption

Illegal mining is common in Vietnam, especially with regard to gold and sand. Furthermore, as stated above, the close relationship between the industry and the government provides a breeding ground for corruption, which is also very common amongst the judicial system and in the natural resource industry (Business Anti-Corruption 2016). Even though Vietnam has legislation against corruption in place, enforcement is lacking. Particularly in the extractives sector, "four out of five mining firms admitted that they have "informal expenses" amounting up to ten percent of revenue and over seven out of ten firms said they rely on "relationships" to access information" (Vietnam News 2016, paraphrased in Business Anti-Corruption, 2016).

Indigenous and minority rights

Vietnam is a one-party state under the firm control of the Communist Party of Vietnam. The government suppresses political dissents and some non-governmental organisations (NGOs) are hindered to operate freely (Minority Rights Group International 2017). Despite the commitments towards the UN Convention on the Elimination of All Forms of Racial Discrimination (ICERD), the Vietnam Committee on Human Rights (VCHR 2012: 4) reports that "ethnic and religious minorities suffer serious violations of their economic and political rights in all aspects of their lives". Besides religious persecution and arbitrary arrest, population displacement and the expropriation from ancestral lands are particularly highlighted (VCHR 2012). This is of major concern when implementing (large-scale) mining projects and periodically leads to demonstrations and conflicts (see chapter 5.2 Social context of mining and conflicts).

5.2 Social context of mining and conflicts

Mining conflicts

Vietnams mining industry is one of the biggest contributors to the GDP and experiences a high growth rate (see chapter 2). At the same time, Vietnam faces long-standing challenges such as the depletion of natural resources, the pollution of air and water, a decline of biodiversity and an increase of solid waste (Vietnam 2035 project 2015; see also chapter 4). These challenges arise from a general conflict between commercial development and sustainability and with that between the interests of society and government. This conflict of interests becomes particularly obvious with regard to mining projects in Vietnam (see e.g. Whitney 2013) and has led to several conflicts around mining projects in the country (see for example Nguyen et al. 2016).

The Nui Phao Mine can be seen as an example of the challenges arising from a conflict between economic importance and impacts on inhabitants and the environment. The mine produces about 7 % of the global supply of tungsten and is therefore of high economic and political importance for Vietnam, since the tungsten market is of growing global significance and is currently clearly dominated by China. The Nui Phao mine is the largest and lowest-cost tungsten mine in the world (White 2016; CSR Asia n.d.). However, most of the 478 ha affected by the Nui Phao Mine were used as residential and agricultural land when the planning of the project began in 2004 (Dihn Thi 2015). Measures were taken

to ensure that affected people would benefit from the project, however, thousands of complaints were filed, especially after construction work started in 2011(Dihn Thi 2015).

The following section on the conflict management at the Nui Phao mining project is mainly based on a dissertation written by Dihn Thi (2015) at the Katholieke Universiteit Leuven on Public Private Partnerships and their contribution to social conflict resolutions in involuntary resettlement exemplified by using the Nui Phao mining case.

The Nui Phao Mining Project – conflict management

The Nui Phao project was planned to affect over 360 ha agricultural and 40 ha residential land. Therefore, about 3,300 households had to be compensated, of which 1,231 household also had to be move permanently (Dihn Thi 2015). The Ha Thoung commune for example, lost one third of its population due to the mining project, including two complete villages (Dihn Thi 2015). This included vulnerable groups such as ethnic minorities and poor families (CSR Asia 2016). Besides resettlement and compensation, also social infrastructure such as roads, railways, businesses, markets, cultural centres, cemeteries, and religious houses were disrupted (CSR Asia 2016). The living conditions and the social everyday life of thousands of inhabitants was permanently changed by the implementation Nui Phao Mining project.

In order to prevent conflicts, a resettlement and compensation program was developed in cooperation with the World Bank in 2006. Following the World Bank Operational Directive 4.30, the resettlement projects were planned to act as development programs, which offered opportunities to the local communities to benefit from the project (Dihn Thi 2015). Based on this, the resettlement project had three core-objectives: the impact on land should be minimized, affected people should improve their economic welfare, and surrounding communities should benefit from the mining project in the long-term (White 2015).

In order to reach these goals, affected people were "entitled to compensation packages, comprising land compensation payments, livelihoods support allowance for job replacement and training and the house-building (resettling) fund" (Dihn Thi 2015: 132). Resettlement sites for a total of 1,925 households were built, which made the project one of the largest resettlement projects in Vietnam (White 2015; CSR Asia 2016). The resettlement project was accompanied by a Community Development Plan (CDP), which was planned to reflect the "company's Corporate Social Responsibility (CSR) through community development and social safeguard programs in the local area" (Dihn Thi 2015: 122). It included an economic restoration fund, measures for infrastructure improvements, and capacity building activities, with the aim to develop "the district from an agricultural area to a more industrially oriented" and urbanised area (Dihn Thi 2015: 117). Affected people who lost more than 260 square meters of agricultural land were able to take part in economic restoration activities and could receive funding for self-employment, agricultural or business extensions and vocational trainings.

Besides the compensation mechanism, a Public Consultation and Information Disclosure Plan (PCDP) was developed and implemented. It included a complaint mechanism for affected people as well as regular public and community meetings (Dihn Thi 2015).

The overall compensation costs were at first estimated at 26 million US$. The amount was then raised to 40 million US§ in 2007 after the dimensions of the planned relocation program became apparent (Dihn Thi 2015). The mining project is reported to have created "1,500 jobs for local labourers" (Dihn Thi 2015: 117) and that "[the] affected populations account for about 56 % of the entire workforce at Nui Phao" (CSR Asia 2016: 4).

The Nui Phao Mining Project – conflicts around the resettlement and compensation program

Even though the resettlement project was planned with respect to the three core-objectives mentioned above and conflict management measures were implemented, thousands of complaints were filed through the official information channels (Dihn Thi 2015). The conflict particularly flared up after

the construction work began in 2011. It was accompanied by non-violent demonstrations and re-occupations (Dihn Thi 2015). However, about 97 % of the complaints were resolved by the end of 2012 by making use of open dialogues (Dihn Thi 2015).

When the mine was put into operation in 2013, only a minority of affected residents was still resisting (Dihn Thi 2015). Most of these resistant households were originally located near the national road 37, and claimed that "their incomes were better generated through non-farm activities such as workshops, commercial shops and restaurants" in their original residential area (Dihn Thi 2015: 134). They stated that the compensation prices offered were "5 times cheaper than the market prices" (Dihn Thi 2015: 134) and compensation packages in general were dissatisfactory (Dihn Thi 2015). The miscalculations were partly caused by implementation agencies, which showed lacking capacities to deal with the huge number of compensation requests (Dihn Thi 2015). Moreover, the authorities were said to not respond to complaints in a timely manner if even at all (Dihn Thi 2015).

Overall, the Nui Phao project had tremendous environmental, economic and social impacts. Thousands were displaced and community structures and social networks were disrupted (Dihn Thi 2015). Even though the project planning phase was supported by the World Bank with regard to conflict management and resettlement, the project led to a "loss of productive assets and income sources" and therefore "may cause a long-term hardship, impoverishment, and detrimental environmental impacts" (Dihn Thi 2015: 118). This examples shows like similar cases in other countries that compensations has its limits and is often not perceived as a permanent solution for mining conflicts by affected communities (Kunjam 2016; see for example also the OekoRess II case study on India).

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 potentials for environmental hazards 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 potential for environmental hazards of the OekoRess I project.

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

The main environmental impacts outlined in this study were the (additional) contamination of soils and water bodies with arsenic, heavy metals and cyanide, the use of land and the emission of noise and dust affecting people's health.

The OekoRess I methodology includes several indicators that reflect environmental hazard potentials. The indicator for the deposit size points out the high use of land, which was outlined as one major environmental impact. The Nui Phao mine is an open pit mine and therefore affects large areas of surface, and leads to deforestation and high noise levels. Furthermore, indicators "paragenesis with heavy metals" and "preconditions for acid mine drainage (AMD)" show high environmental hazard potentials and therefore adequately reflect the actual environmental impacts of contaminated soils and water bodies. The indicators "use of auxiliary substances" and "mining waste management" indicate a high environmental hazard potential, which is also reflected in the actual environmental impacts, as the contamination of soils and water bodies mainly stems from tailings and waste material (however, the contamination stems from tailings of recent and past mining activities).

Although the indicator for water stress ("Water Stress Index (WSI) and desert areas") highlights a high environmental hazard potential, the current environmental impacts concern the problem of water contamination, not the general lack of water or a competition between mining and other sectors or local communities over the resource itself. This might be the case due to water recycling measures of the mining company.

The indicator "remediation measures" shows a low potential for environmental hazards because the mining company has a mine closure plan in place. The research on current environmental impacts was able to confirm this and additional information on MASAN building up financial reserves for rehabilitation was found.

The indicator "conflict potential with local populations" points out a high environmental hazard potential, in a sense that there is a rather high probability that the assessed environmental hazard potentials

result in actual environmental damage. The governance analysis showed that – in particular when focusing on the environment – Vietnam's legal system is "relatively good". Nevertheless, there is a lack of implementation, corruption is common and non-compliance with legislation is hardly ever sanctioned. As shown in the environmental impact analysis, numerous complaints about environmental impacts were actually filed.

Main findings of the governance analysis

The governance analysis showed that, overall, Vietnam's governance is characterised by sound regulations and strategies, but a lack of coherence between them, and a lack of cooperation between the ministries in charge. Furthermore, the country struggles to balance economic and sustainable development and lacks implementation in particular of its environmental laws. Furthermore, non-compliance with legislation is hardly ever sanctioned and the close relationship between politics and economy provides a breeding ground for corruption.

The conflict of interests between economic and sustainable development becomes particularly obvious with regard to mining projects and has led to several conflicts around mining in the country. However, with regard to the Nui Phao mining project, a compensation mechanism was in place.

Do existing governance indicators reflect Vietnam's governance gaps and challenges?

Vietnam's overall average sector governance is reflected well in the set of Worldwide Governance Indicators (WGI), however, the rank varies between the different underlying indicators (World Bank 2017c).

Vietnam has by far the lowest value for WGI Voice and Accountability in comparison to its other WGI values, with a percentile rank[8] of only 10.8. This reflects the overall situation in Vietnam well. The indicator captures the citizen's ability to participate in selecting the government, the freedom of expression and free media. Vietnam is an authoritarian state ruled by a single party, which outlawed all other political parties. The general human rights record is poor and the government represses freedom of expression, belief, and assembly (U.S. Department of State 2016).

All of the other WGI indicators also reflect the situation in Vietnam well and range in average percentiles between 33.7 and 55.3: Vietnam's second lowest value is the WGI Regulatory Quality, with a value of -0.50, and a percentile rank of 33.7. This indicator describes the ability of the governments "to formulate and implement sound policies and regulations" that also promote private sector development. As the governance analysis shows, this is a weakness and thus the indicator reflects the situation in Vietnam well. Vietnam's third-lowest value is the WGI Control of Corruption with a value of -0.45 and a percentile rank of 39.4, which also reflects the situation.

The best rated WGIs are the indicators on Government Effectiveness, on Rule of Law and on Political Stability and Absence of Violence, which all reach values around 0 (0.08, 0.27 and 0.0), reflecting the situation in Vietnam well. All of the indicators range around the 50th percentile, making it an average result.

An index that aims at specifically capturing Vietnam's performance of the protection of human health and of ecosystems is the Environmental Performance Index (EPI) (Yale University n.d.). Vietnam ranks 131 out of 178, scoring 58.50 out of 100. This index reflects Vietnam's overall average to weak performance well. The index measures a country's performance in several areas such as health impacts, air quality, water and sanitation, agriculture and forest. Unlike the WGI, the EPI uses scientific data in order to analyse a country's performance, not existing indicators, which are then combined to a new index.

Furthermore, it does not measure for example legislations in place to protect human health and ecosystems, but a country's performance regarding the success or the failure to achieve specific thresholds.

Vietnam's sector governance and its associated problems are very well reflected in the Fraser Policy Perception Index surveyed yearly by the Fraser Institute[9]. Vietnam ranks only 99th of 109 countries in the world in terms of attractiveness of its policy environments (34.91/100 points) (Fraser Institute 2015). Interestingly, Vietnam's score fell by almost 20 points compared to previous years, which reflects "worsening perceptions of respondents for the quality of infrastructure and trade barriers" (Fraser Institute 2015: 56). Interviewees highlighted uncertainties around an increase in royalties and the constantly changing regulatory environment as major points of concerns (Fraser Institute 2015: 56). With these results, the assessment particularly points towards weaknesses identified in the governance analysis in terms of uncertainties around the administration, enforcement of existing regulations as well as regulatory duplication and inconsistencies. This higher granularity in reflecting the actual situation in Vietnam seems to be a result of the type of data the Fraser Index uses. The expert assessment of professionals actually working in the mining sector on 15 policy factors via questionnaires seems to reflect the actual sector-governance situation in Vietnam very accurately. With this, the Fraser Index combines qualitative with quantitative approaches.

The Global Peace Index (GPI) displays a country's level of peacefulness according to a ranking in three domains: ongoing and internal conflicts, levels of harmony or discord within a nation and a country's militarisation (IEP 2016). Vietnam is rated high (on a scale from very high to very low) which seems to reflect the country's peacefulness well. However, the index accounts for the whole country, and is not able to reflect subnational differences and regional or sector-specific (mining) conflicts.

The Corruption Perception Index (CPI) rates countries on how corrupt their public sector is seen by experts (Transparency International 2016). Vietnam ranks 113 out of 176 countries assessed, which reflects the results of the governance analysis well. Even though Vietnam has legislation against corruption in place, enforcement is lacking, which is particularly true for the extractives sector.

Conclusion

Vietnam's overall average (with a tendency to weak) sector governance is well reflected in key governance indices of the WGI. Furthermore, the existing indices and indicators show in some cases a good ability to also reflect the specific and nuanced governance challenges in the mining sector of Vietnam.

This was particularly true for the Fraser Policy Perception Index that reflected the specific challenges of Vietnam's sector governance best, which might be explained by it being a perception index based on an expert survey. This will have to be tested as part of the following case studies; however, the results of the previous case studies already underline this finding.

In general, the governance indicators provide a useful explanatory link between environmental hazard potentials and the occurrence of actual environmental impacts. Vietnam's relatively sound regulations and strategies are unable to prevent environmental damages resulting from mining projects comprehensively, due to an implementation gap. This implementation gap is mirrored in Vietnam's weak scores for Regulatory Quality and Control of Corruption (WGI). The gap is further captured by the EPI, which focusses on a country's actual performance (i.e., implementation). Vietnam's weak implementation capacity results in a low EPI score. For the case of Vietnam, the governance indicators thus provide information on the circumstances under which actual environmental harm becomes more likely.

[9] In case of Vietnam, data for 2015 had to be used, as there were insufficient responses to a number of the jurisdictions surveyed and Vietnam could not be included in the 2016 report.

Table 6-1: Overview of the governance indicators

Indicator	India	Year	Indicator measures…	Applicability
Voice and Accountability (WGI)	-1.33 (estimate between -2.5 and 2.5) 10.8 (percentile rank terms from 0 to 100, with higher values corresponding to better outcomes)	2015	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 weak governance performance in this specific area.
Political Stability and Absence of Violence (WGI)	0.0 (estimate between -2.5 and 2.5) 48.6 (percentile rank terms from 0 to 100, with higher values corresponding to better outcomes)	2015	Political Stability and Absence of Violence/Terrorism measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism.	Reflects well the overall average governance and Vietnams' political stability and violence.
Government Effectiveness (WGI)	0.08 (estimate between -2.5 and 2.5) 55.3 (percentile rank terms from 0 to 100, with higher values corresponding to better outcomes)	2015	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 overall average governance.
Regulatory Quality (WGI)	-0.50 (estimate between -2.5 and 2.5) 33.7 (percentile rank terms from 0 to 100, with higher values corresponding to better outcomes)	2015	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 overall weak to average governance performance in this area. The governance analysis showed that the implementation of sound regulations is a weakness and thus the indicator reflects the situation in Vietnam well.

Rule of Law (WGI)	-0.27 (estimate between -2.5 and 2.5) 46.2 (percentile rank terms from 0 to 100, with higher values corresponding to better outcomes)	2015	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, the police, and the courts, as well as the likelihood of crime and violence.	Reflects well the overall average governance performance.
Control of Corruption (WGI)	-0.45 (estimate between -2.5 and 2.5); 39.4 (percentile rank terms from 0 to 100, with higher values corresponding to better outcomes)	2015	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 well the overall average to weak governance in this area
Environmental Performance Index (EPI)	Rank 131 of 178, Score 58.50 (out of 100)	2016	The protection of human health and protection of ecosystems.	Reflects well the overall weak governance in the environmental sector.
Fraser Policy Perception Index	Rank 99 of 109, Score 34.91 (out of 100)	2015	The index measures the overall policy attractiveness and the country's government policy on attitudes towards exploration investment	Reflects very well the overall average to weak governance in the mining sector. It particularly points towards weaknesses, which were identified in the governance analysis.
Global Peace Index (GPI)	1.906 (high, scale of 1-5, overall rank 59)	2016	Countries' level of peacefulness	Reflects the situation in Vietnam well. However, the index accounts for the whole country, and is not able to reflect subnational differences and regional or sector-specific conflicts
Corruption Perception Index (CPI)	33 (rank 113/176; scale 0 -100)	2016	Describes the perception of the corruption in the public sector by experts	Reflects the situation in Vietnam well.

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