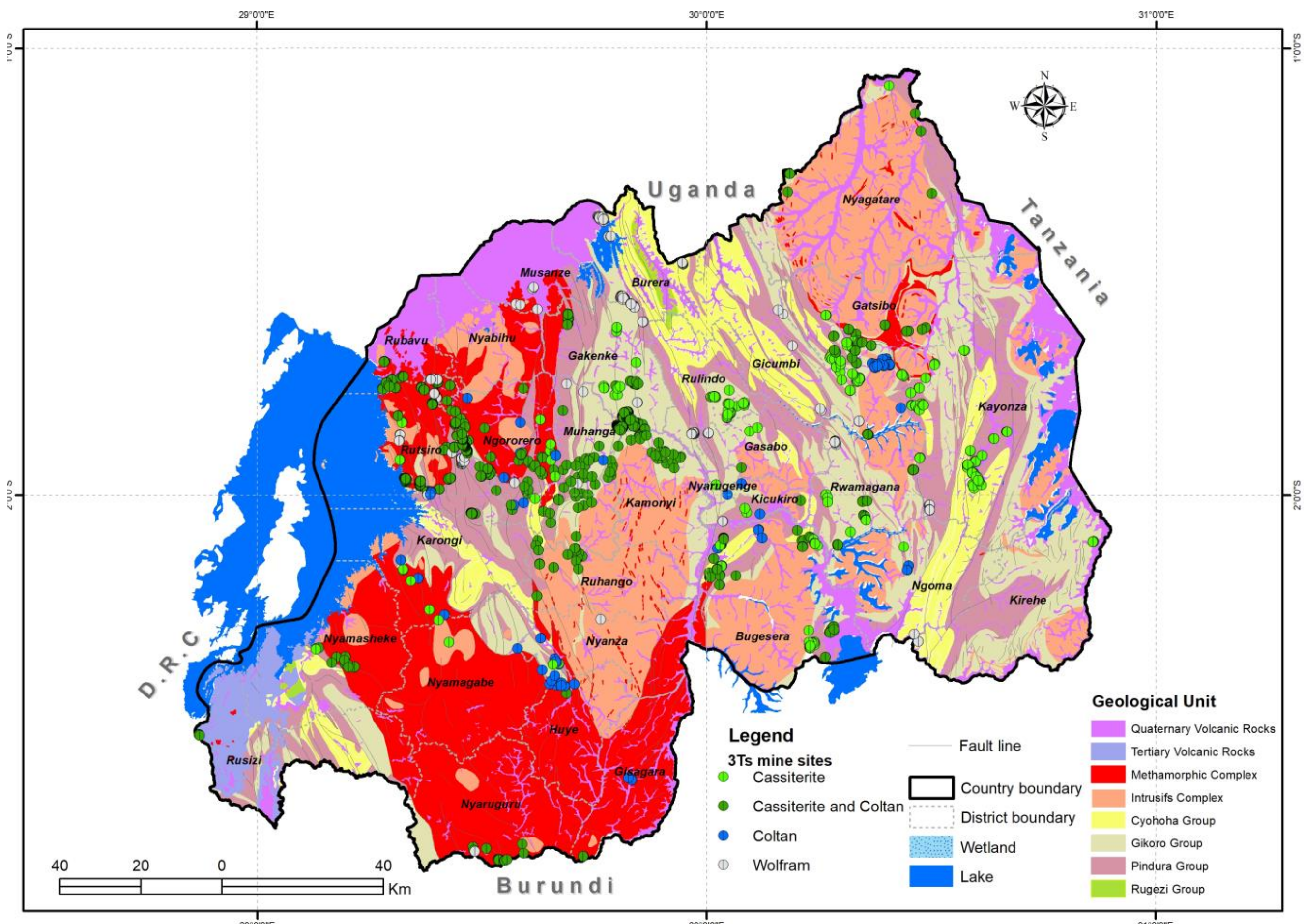
RWANDA
NATURAL CAPITAL ACCOUNTS - Minerals resource flows

Version 1 – December 2019



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NISR: KN 2 Av, 36, Kigali, Rwanda
PO. Box 6139, Kigali; Tel: +250 252 571 035; Email: info@statistics.gov.rw

Rwanda Mines, Petroleum and Gas Board (RMB): KN 4 Ave, Kigali, Rwanda
P.O.Box 937, Kigali; Tel: +250 788 386 220; Email: info@rmb.gov.rw

Ministry of Finance and Economic Planning (MINECOFIN), KN 12 Ave 3, Kigali, Rwanda
PO Box 158, Kigali; Tel: +250 252 577 581; Email: info@minecofin.gov.rw

Cover image developed by Jean-Pierre Bizimana using shapefiles obtained from the RMB with respect to (i) the geology units based on Theunissen (1991), and (ii) the GPS-corrected location of mine sites according to RMB unpublished records.

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Acknowledgements

The Rwanda Natural Capital Accounts (NCA) for Mineral Resource flows, Version 1 [Draft] has been prepared through a collaborative effort of Ministry of Finance and Economic Planning (MINECOFIN), Rwanda Mines, Petroleum and Gas Board (RMB) and the National Institute of Statistics of Rwanda (NISR)[1]. The Technical Working Group on Mineral Accounts included Tuyishime Ngondo Modest, Statistician, Ministry of Environment; Donat Nsengumuremyi, Director of mineral extraction and processing unit, Rwanda Mining Gaz and Petroleum Board(RMB); Joseph Butera, Mineral Economist & Investment, Rwanda Mining Gaz and Petroleum Board(RMB); John Kanyangira, Director of Support Services in Mining Investment and Business Development, Rwanda Mining Gaz and Petroleum Board(RMB); Alain Joseph Ntenge, Geologist, Rwanda Mining Gaz and Petroleum Board(RMB); Aloys Nzavurimana, Planning Specialist, Rwanda Mining Gaz and Petroleum Board(RMB); Ivan Patrick KAYITARE, Statistician, National Institute of Statistics of Rwanda (NISR); Ephrem Rutagarama, Statistician, National Institute of Statistics of Rwanda (NISR) contributed to the mineral accounts analysis and access to mineral data sources.

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[1] This NCA effort for land began in 2014, working closely with officials from the Ministry of Natural Resources (MINIRENA) and Rwanda Natural Resources Authority (RNRA). In early 2017, RNRA was replaced by three specialized bodies: Rwanda Land Management and Use Authority, Rwanda Water and Forestry Authority, and Rwanda Mines, Petroleum and Gas Board. Recently, the Ministry of Natural Resources was divided into a Ministry of Environment and a Ministry of Land and Forests. Key technical staff have continued to support the process during this transition.

Executive Summary

Mining in Rwanda commenced in the early part of the 1900's and the focus has mainly been on cassiterite, coltan and wolfram. These minerals, after beneficiation, renders tin, tantalum and tungsten respectively – the so-called 3T metals. Given this long history, the Government of Rwanda has placed much emphasis on the role and contribution of the mining sector to assist in the economic development of the country. The sector has thus been steadily privatised and transformed over the past two decades from a publicly run one into an exclusively privately driven industry. New legislation has also been introduced in 2018 to assist in the modernisation of the sector. This legislation is supported by policy aimed at promoting increased professionalism within the industry, notably among the artisanal small miners, as well as the introduction of local beneficiation.

In 2018 mining has contributed 2.4% to GDP with total export earnings from mining of about US$346 million. The aim is to accelerate the mining sector's contribution to export to US$1.5 billion by 2024. It is anticipated that this can be accomplished by, among others, doubling the exports from the 3T's from US$142 million in 2018 to about US$300 million and to advance the export earnings from other minerals such as gold. Due to the development of other minerals and metals, the proportionate share of the 3T's contribution to mining exports has declined from about 100% in 2014 to 41% in 2018.

In addition to its contribution to GDP and exports, the mining sector is a large employer. The mining sector employs about 54,000 people, or about 2% of the total number of people employed. The majority (about 97%) are informally employed with only about 1,200 formally employed. By far the most people participating in mining are therefore doing so on a part time basis to augment their income in addition to being employed elsewhere, mainly in agriculture. They embark on mining activities as contract workers when it is not planting or harvesting season.

While mining, comparatively speaking, is a small sector it does have an impact on the quality of all the other natural resources of the country and the productive capability of Rwanda as a whole. The Government of Rwanda therefore embarked on the development of natural capital accounts for mining. Through these accounts it is hoped that information will be obtained whereby the mineral sector of Rwanda can be expanded and pathways be found to reduce the role of artisanal and inefficient mining techniques while improving the value of the output and the contribution to foreign exchange earnings and rent capture by the government. The compilation of the natural capital mineral accounts is therefore a way of deepening the understanding of the sector, collate consistent time-series data, and examine the social and environmental costs issues that are arising and raising serious concern.

One of the objectives of the monetary accounts is to generate consistent and comparable datasets for understanding trends of and contributions by the natural resource sector to economic development. One subset thereof linked to minerals accounts is the compilation of the resource rents. Natural resource rents are a measure of the scarcity value of extractive resources such as minerals and is calculated as the surplus value after all costs, including normal profits have been accounted for. The rent is therefore the difference between the turnover or total sales of the commodity (price multiplied by quality) and the cost of extraction, production and operation as well as the cost of capital (i.e. depreciation) and the provision for normal profits (the minimum expected return on capital).

As is frequently the case, the exact data to estimate the resource rents were not available. It was, however, possible to estimate such. This has been done using a combination sources. The production data and the export values are collated and published by the Rwanda Mines, Petroleum and Gas Board (RMB), National Institute of Statistics in Rwanda (NISR) and the Rwanda National Bank (BNR). The NISR, through its Integrated Business Enterprises survey (IBES), annually surveys a sample of companies in all economic sectors to, among others, determine the expenditure and income structures of all the economic sectors. Companies in both mining and that of mineral trade is surveyed based on a random and statistically significant sample. IBES provides data on the income and expenditure structure of all the economic sectors and is the most credible source in Rwanda with respect to this currently. This income and expenditure structures are used to estimate the proportion of each expenditure item, such as intermediate consumption, to total expenditure and total sales. These proportions are then applied to the estimated turnover levels to estimate the level of each cost item. The rent estimates are therefore based on, in part, derived numbers and not directly observed or surveyed data.

The results indicate negative rents for all minerals in all the years of analysis (2012 – 2016) with that of 2016 being about -US$7 million. One of the consequences of the negative rents are that the sector is cash-strapped or illiquid. This liquidity constraint in the sector hampers its ability to honour its commitments with respect to safety, health and the environment, among others. It therefore might, at least in part, explain the lack in investment in health, safety and environmental concerns – leaving a negative legacy of waste dumps, mine tailing dams, and land degradation and the consequences thereof on water and related aspects. This legacy also has a negative impact on the mining sector's reputation in Rwanda. These negative rents are likely the result of any or a combination of factors. These factors are:

1) Low commodity prices that do not fully reflect the value of the scarce resource;
2) System-wide inefficiencies leading to too low production;
3) High production costs (relative to the level of production); and/or
4) Difficulty in accessibility of the resource or low quality of the ore.

These plausible reasons for the negative rents, in and by themselves, also point towards possible remedial actions. First and foremost, only a marginal increase of in the average unit price of between 3,5% and 3,6% is required to turn the negative rents to zero. Increases in the average unit price of, for example, 9% or 12% in 2016 has the potential of generating resource rents of about US$11 and US$17 million respectively. A sector-wide change of between US$18 and US$ 24 million from the actual 2016 level of -US$7 million. There is furthermore much scope for such price increases as the difference between the average unit prices of the minerals received and that of the international metal prices are vast. The unit export price of cassiterite is about 55% of that of tin. The unit export price of coltan is only about 23% that of tantalum, while the unit export price of wolfram is even lower at about 18% that of tungsten.

Mechanisms, especially structurally, must be explored to seek ways to improve the liquidity of the sector domestically. This change is required to enable the sector to advance on its desired growth path while not compromising the health and safety of Rwanda's people or that of its environment. To achieve these increases in domestic prices an in-depth sectoral analysis is required. Improvements in sector-wide efficiency is also required as well as seeking ways to enhance and promote local beneficiation. Through local beneficiation Rwanda will also be able to close the gap in the average unit price of the exported commodity.

In conclusion, while the mineral resource accounts of Rwanda indicate negative resource rents, it also points to meaningful and progressive ways towards change. In doing so the mineral accounts also contribute towards measuring progress in terms of the United Nations' Sustainable Development Goals (SDGs).

Abbreviations

3T's	Tin, tantalum and tungsten
AGA	AgloGold Ashanti
ASM	Artisanal small mining
BNR	Rwanda National Bank
BRGM	Bureau de Recherches Géologiques et Minières
COPIMAR	Coopérative de Promotion de l'Industrie Minière Artisanale au Rwanda
DRC	Democratic Republic of Congo
EDPRS	Economic Development and Poverty Reduction Strategy
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
FONERWA	National Fund for Environment
GDP	Gross domestic product
GIS	Geographic Information System
GMD	Geology and Mining Department
GoR	Government of Rwanda
IBES	Integrated Business Enterprises Survey
ICGLR	International Conference on Great Lakes Region
ICMM	International Council on Mining and Metals
ICT	Information and communications technology
ISIC	International Standard Industrial Classification
ITRI	International Tin Research Institute
iTSCi	ITRI Tin Supply Chain Initiative
LFS	Labour Force Survey
LUTOT	Land use trade-off tool
MIDIMAR	Ministry of Disaster Management and Refugees Affairs
MINETAIN	Société des Mines d'Etain du Rwanda-Urundi
MINIFOM	Ministry of Forestry and Mines
MINIFRA	Ministry of Infrastructure
MINIRENA	Ministry of Natural Resources
MoE	Ministry of Environment
NGO	Non-Governmental Organisation
NISR	National Institute of Statistics in Rwanda
NPV	Net Present Value
NST1	National strategy for transformation (version 1)
OECD	Organization for Economic Cooperation and Development
OGMR	Office de la Géologie et des Mines du Rwanda
OHS	Occupational Health and Safety
RAPEP	Rwanda Association of Professional Environment Practitioners
RDB	Rwanda Development Board
REDEMI	Régie d'Exploitation et de Développement des Mines
REMA	Rwanda Environment Management Authority
RINR	Illegal Exploitation of Natural Re-sources
RLMUA	Rwanda Land Management and Use Authority
RMB	Rwanda Mines, Petroleum and Gas Board
RMCA	Royal Museum for Central Africa

RwF	Rwandan Franc
RWFA	Rwanda Water Forestry Authority
SDG	Sustainable Development Goal
SDR	Social discount rate
SEEA	System of Environmental-Economic Accounting
SIA	Social impact assessment
SOMIRWA	Société Minière du Rwanda
SOMUKI	Société Minière de Muhinga et de Kigali
TWG	Technical working group
U.M.H.K.	Union Minière du Haut Katanga
UN	United Nations
UNDP	United Nations Development Programme
US$	United States Dollar
UR	University of Rwanda

1. GENERAL INTRODUCTION AND OVERVIEW

1.1 Mining within the context of NST1 and Vision 2050

Rwanda has a long and rich history in mining (see Appendix 1), a history dominated by the so-called 3T's, tin, tantalum, and tungsten. It should be noted that these three metals are derived from the minerals cassiterite, coltan and wolfram respectively. The minerals are mined in Rwanda and exported, and the metals are subsequently extracted from them. Through the Rwanda Mines, Petroleum and Gas Board (RMB), the mining sector and the Government of Rwanda (GoR), Rwanda has high hopes for the mining sector to contribute to national development, such as the creation and maintenance of a significant number of off-farm jobs, export revenues, and foreign direct investments (Rwanda 2017). It is against this backdrop that the GoR has strived to promote and regulate the mining sector for transformation, growth and development, and ensure that all Rwandans derive sustainable benefit from the country's mineral wealth (Rwanda 2018).

Rwanda's Vision 2020 thus identified natural resources as one of three cross-cutting issues (the others being gender equality, and science, technology and ICT) to usher in economic development. Rwanda (2000) defines cross-cutting as goals to be pursued, but they also contribute to the development of other pillars and overall goals of the Vision.

Vision2020, NST1, Vision2050 in context:

After the election of President Kagame in 2017, the Government of Rwanda reflected on what had been achieved over the previous 7 years (2010-2017) and set new targets for the next 7 years. This is reflected in a 7-year Government Program for the period 2017-2024 formally known as the NST1. The 7-year Government program coincided with the implementation of the remainder of the Economic Development and Poverty Reduction Strategy (EDPRS2 2013-2018: Rwanda 2013a). EDPRS2 was part of implementation strategies of the overarching Vision 2020, which ends with year 2020, and also covers the first four years of a new 30-year Vision for the period up to 2050, officially referred to as Vision 2050 (Rwanda 2017).

Rwanda's 30-year Vision for the period up to 2050 (Rwanda 2017) outlines a strategic pathway built around economic, social, and transformational governance pillars. The economic transformation pillar proposes to accelerate inclusive economic growth and development founded on the private sector, knowledge and Rwanda's natural resources.

The economic transformation pillar of Vision 2050 has six objectives. Three of them are directly related to mining, namely: export promotion and expansion, job creation, and sustainable exploitation of natural resources. Priority strategic sectors with high potential for growth and employment include mining will be developed and supported. Sector development intervention packages will combine direct support (such as public co-investment) and indirect support through tailored regulatory reform. The GoR has vowed to invest resources into mining exploration and engage the private sector in extraction, value addition and in-country processing in a bid to attain a structural shift in the export promotion and expansion (Rwanda 2017).

National strategy for transformation (version 1) (NST1) has identified the mining sector as one of the pillars for achieving the goals of NST1. Preliminary studies (Rwanda 2017) indicated potential significant reserves in rare earth minerals, petroleum and gas that offer potential if they are fully explored and exploited. In addition, considering the existing reserves in energy generation, processing and value addition, mineral products present viable investment opportunities. Recent statistics, however, show that mineral exports amounted to about US$346 million in 2018, down from US$374 million in 2017

(BNR 2019). This is well below the NST1 target of US$800 million by 2020. In 2018 mining has contributed 2.4% to GDP with the three main mining-related export commodities (cassiterite, coltan and tantalum) contributing about 15% to the value of total exports.

Under the new mining policy (RMB 2018a), the RMB is encouraging mining operators to embrace value addition of mineral resources and increase export revenues to achieve the NTS1 target of US$1.5 Billion mining exports revenues by 2024. As of August 2018, the total number of mine sites that were extracting the 3T's was estimated to 3,041. The mine sites comprising both cassiterite and coltan were (1,942), followed by cassiterite mines (487), wolfram mines (275), and coltan mines (237) (RMB 2018b). The main mining sites together with the country's geological units are shown in Figure 1.

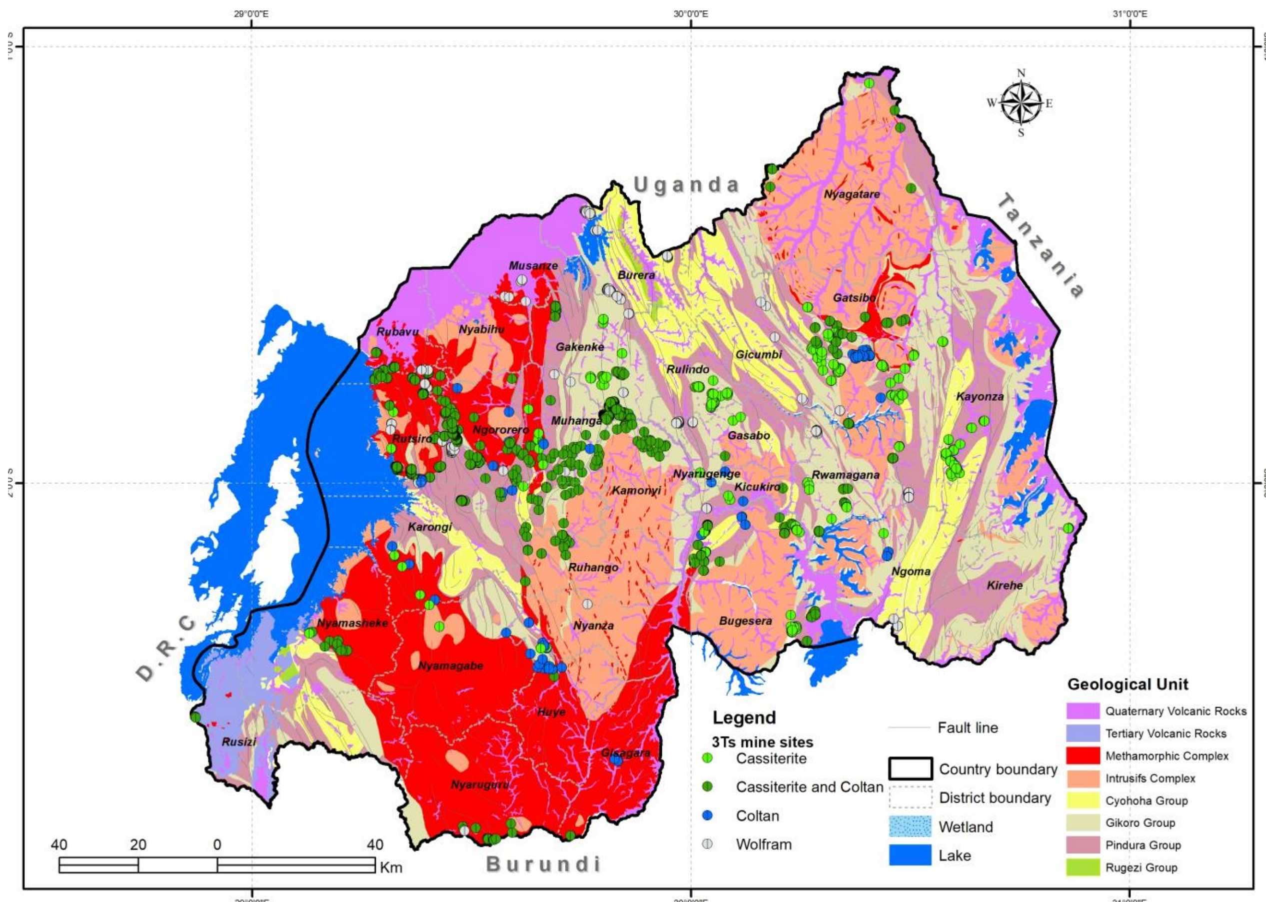

Figure 1: Location of cassiterite, coltan and wolfram mine sites in Rwanda
Source: RMB (2018c) based on Theunissen et al. (1991).

To achieve the sought-after development outcomes, NST1, among others, places a heavy emphasis on the restructuring of artisanal mining that occupy 70% of Rwandan mining activities. Restructuring includes the reorganisation of artisanal miners into cooperatives, and to professionalise their practices through training, financing and equipment. A supporting facility (the Mining Supplies Hub) is expected to be established to serve as a One Stop Centre for providing technology, information, and capacity building for business operators. Artisanal miners will be supported to consolidate their concessions and create mineral aggregate centres to facilitate their access to technologies, investment, skills development opportunities, equipment and financing.

Under NST1, the private sector will continue to be encouraged to invest in mineral processing and value addition to attract processing plants to be constructed countrywide to smelt ores. In 2017, the Rwanda Development Board (RDB) attracted 137 investment commitments economy wide totalling US$1.67 billion and expected to generate 37,548 jobs (RDB 2017). Compared to US$1.16 billion investments attracted in 2016, this was an increase of about 29.3 per cent in a year. Following the anticipated identification of Gemstones in the Western province, a regional Gemstone Cutting and Polishing Hub will be established for processing and value addition. In addition, the sector is encouraged to upgrade old mining infrastructures and equipment. It is also crucial to establish linkages between mineral exploitation and the construction industry that would use locally made material such as brick clays, granites, sand, and gravel at competitive prices.

The Rwandan mineral sector is, however, performing sub-optimally (World Bank 2014). Strict measures are therefore required for all current and for future mining activities to ensure sustainable mining exploitation by adopting environmentally friendly standards in dealing with waste management and environmental degradation. Mining licenses are expected to ensure operators adopt the model mining concept and align activities with Mining District Plans. Furthermore, standards enforcement will continue to be strengthened across all mining activities to decrease adverse effects including siltation and sedimentation (Rwanda 2017).

1.2 Mining laws and policies

Rwanda is known to have and to continuously strive to put in place good governance and strong legal and policy frameworks in all economic sectors. Five government institutions are paramount to the mining sector operations, namely: The Ministry of Infrastructure (MINIFRA), the Ministry of Environment (MoE), Rwanda Environment Management Authority (REMA), RMB, and RDB.

Rwanda has made significant strides to improve its regulatory policies and practices so that they approach international best practices (see Appendix 2 for a list of mining policies, laws and ministerial orders governing the sector). The new law governing Mining and Quarry Operations (Law No 58/2018 of 13/08/2018; Rwanda 2018) seeks to promote professionalism and growth of the mining sector while giving a new lease of life to the mineworkers whose safety at work has been the cause for concern (Nsabimana 2018).

The GoR has also enacted responsible practices in the mining sector through appropriate sector regulation and governance, followed up by on-the-ground progress, both at a national level (e.g., through piloting the Certified Trading Chains approach from 2008-2011, and with the progressive rollout of the ITRI (Tin industry body, former International Tin Research Institute), tin supply chain initiative, iTSCi (ITRI Tin Supply Chain Initiative), since late 2010) and integrated into the regional context as a driving member state of International Conference on the Great Lakes Region's (ICGLR) Regional Initiative against the Illegal Exploitation of Natural Resources (RINR).

1.3 The need for mineral resource accounting in Rwanda

Given the wide-spread impact of mining on the economy, the environment and the livelihoods of people in Rwanda, there is a need to report on the contribution of mining, most notably the 3T's to the Rwandan economy. This report therefore documents the contribution of the 3T's using a natural capital accounting perspective. The natural capital accounts of the extractive resources sector comprise physical and monetary stock accounts (not included here), and physical and monetary flow accounts.

Through the development of these accounts it is hoped that information will be obtained whereby the mineral sector of Rwanda can be expanded and pathways be found to reduce the role of artisanal and inefficient mining techniques while improving the value of the output and the contribution to foreign exchange earnings and rent capture by the government. There are therefore high hopes for increasing investment and production. This, however, should be done in a way that is not detrimental to the safety of the people and the environment of Rwanda.

For the above reasons, the Government is determined to develop natural capital mineral accounts for the sector as a way of deepening the understanding of the sector, collate consistent time-series data, and examine the social and environmental costs issues that are arising and raising serious concern. Mineral resources accounts are expected to help in providing more accurate data for government management and oversight as well as setting appropriate mining taxes or fees and determining trends in production, value addition and employment in different mineral sectors. One of the main contributions of the natural capital accounts, in addition to restructuring existing data into a replicable and internationally endorsed format, is that it enables the calculation of the mineral resource rents. These will serve government's interest in knowing how to optimize the resource rents and utilize them through re-investment in physical, human and social capital. Mineral natural capital accounts could further inform plans for increasing investments and production from the mining sector and consequently its contribution to GDP and foreign exchange earnings plus the social environmental costs related to the mining sector.

To implement the above, Chapter 2 commences with a discussion on the background to mining in Rwanda followed by a discussion of the materials and methods used to compile the mineral accounts. The chapter is concluded with the accounts themselves and an estimation of the resource rents. Chapter 3 provides a brief overview of the environmental impacts of mining and Chapter 4 concludes with policy recommendations. These recommendations are based on the accounts themselves as well as various workshops held with the technical working group (TWG) and members of the RMB staff.

2 MINERAL ACCOUNTS FOR RWANDA

2.1 Mining's contribution to the economy

The mining sector is considered one of Rwanda's key sectors from an economic development perspective. Its contribution to GDP is provided in Table 1 and Figure 2 with the overall structure of the economy provided in Figure 3. In current prices mining has increased its share in the economy from about 0.2% in 1999 to 2.5% in 2018, with a peak in 2014 of 2.7%.

Table 1: Mining's contribution to the Rwandan economy

Year	GDP at current 2014 prices	Mining GDP at current 2014 prices	Mining GDP as % of GDP	Exchange rate
	(million US$)	(million US$)	(%)	(RwF:US$)
1999	1,817	3	0.2%	334
2000	1,733	3	0.1%	390
2001	1,675	14	0.8%	443
2002	1,678	4	0.3%	475
2003	1,846	6	0.3%	538
2004	2,097	14	0.7%	575
2005	2,585	18	0.7%	557
2006	3,192	42	1.3%	552
2007	3,876	79	2.0%	547
2008	4,923	93	1.9%	547
2009	5,452	58	1.1%	568
2010	5,851	77	1.3%	583
2011	6,650	170	2.6%	600
2012	7,433	158	2.1%	614
2013	7,618	192	2.5%	647
2014	8,003	215	2.7%	683
2015	8,289	183	2.2%	720
2016	8,478	174	2.1%	787
2017	9,135	219	2.4%	832
2018	9,511	237	2.5%	861

Source: NISR (2019a)

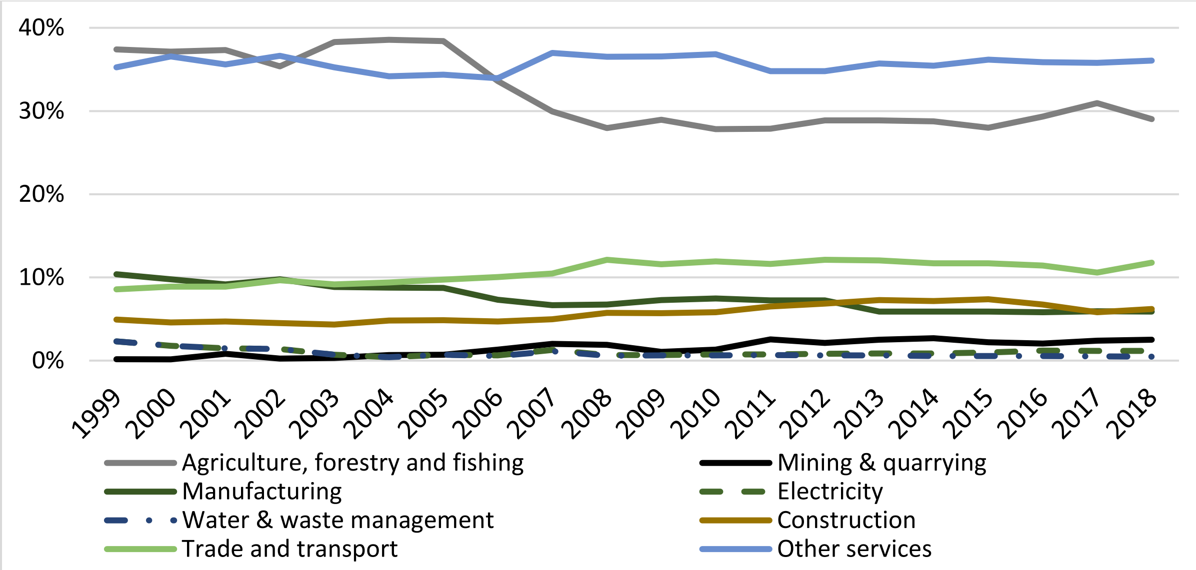

Figure 2: Sectoral GDP as a percentage of total GDP in current prices

Source: NISR (2019a)

As can be seen in Figure 3, agriculture, contributing 29% to the GDP is the largest sector in the economy, followed by the trade and transport sector (11.8%), construction (6.2%) and manufacturing (5.9%). Mining and quarrying, although important from a strategic perspective, is therefore one of the smaller sectors from a GDP perspective.

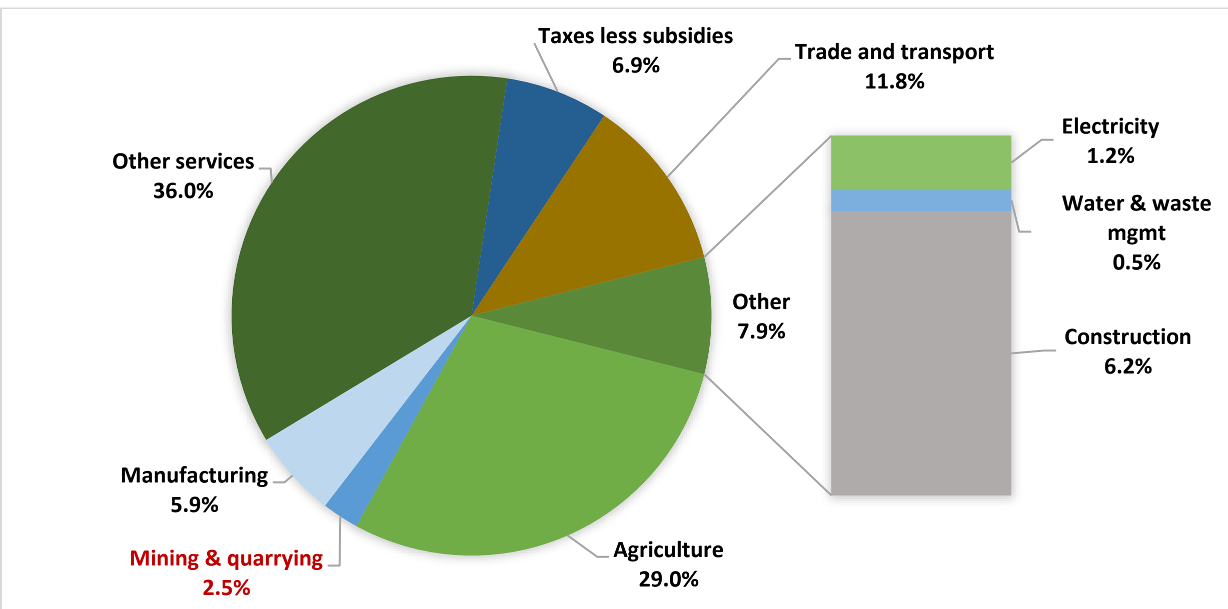

Figure 3: Composition of GDP in current prices: 2018

Source: NISR (2019a)

Mining's strategic importance can be seen in its contribution to exports (Figure 4). The 3T's have contributed as much as 37% to total goods export (2013), but that has declined to 15% in 2017, mainly as a result of declining commodity prices, increases in the exports of other minerals and that of tourism. In as recent as 2014 the 3T's were responsible for almost all the mining-related export revenues earned by Rwanda. Due to the sharp rise in other earnings, notably gold, the proportionate share in the contribution of the 3T's declined to 41% of the export earnings (BNR 2019).

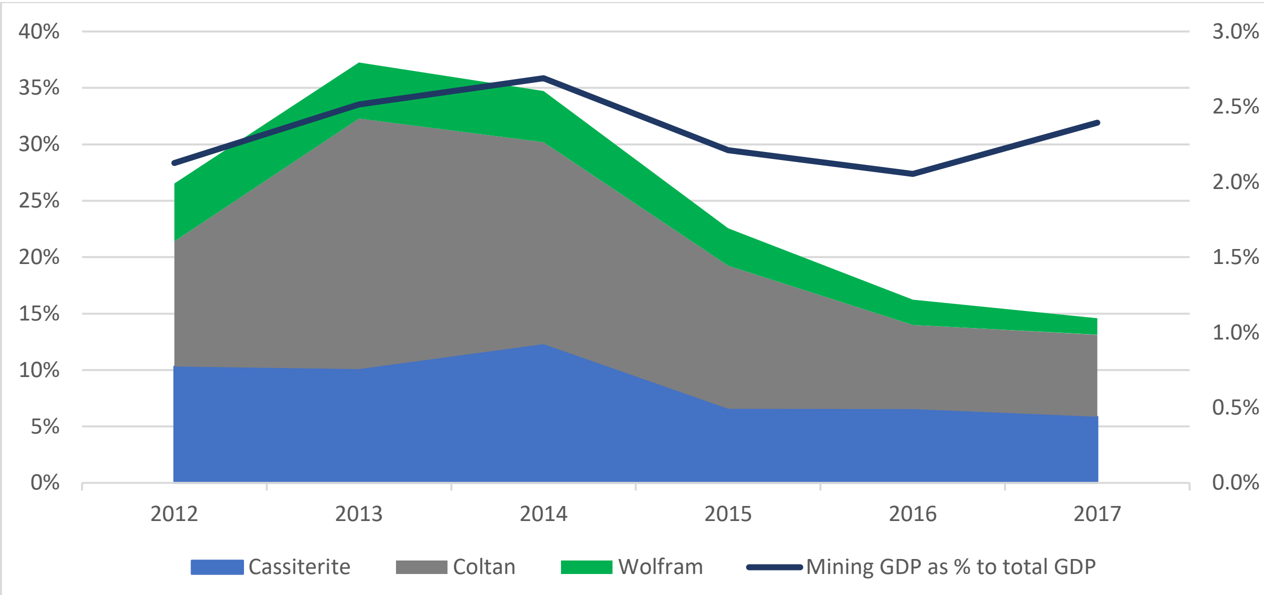

Figure 4: The contribution of the 3T's to total exports and mining's contribution to GDP
Source: NISR (2019a) and RMB

In addition to its contribution to GDP and exports, the mining sector is perceived as an important employer. According to the Labour Force Survey (LFS) (see Table 2 and Figure 5), mining employs about 54,000 people, or about 2% of the total number of people employed. The majority (about 97%) are, however, informally employed with only about 1,200 formally employed. The relatively low number of people employed in the formal sector is confirmed by the Integrated Business Enterprise Survey (IBES) that estimates that about 5,000 people, or 2.3% of the total formally employed, are within the mining and quarrying sector (see Table 3). There is therefore a slight discrepancy in the numbers reported by the LFS and IBES. This is due to different sampling techniques and reporting purposes. Irrespective the source and the survey used it is evident that by far the most people participating in mining are doing so on a part time basis to augment their income in addition to being employed elsewhere, mainly in agriculture. They embark on mining activities as contract workers when it is not planting or harvesting season.

Table 2: Employment in the mining sector: According to LFS

		Total	Male	Female	Urban	Rural
Employed population	2017	2,959,965	1,690,031	1,269,934	814,394	2,145,571
	2018	3,096,278	1,719,527	1,376,751	773,971	2,322,307
Mining and quarrying (2017)	Total	54,618	49,756	4,862	2,749	51,869
	2017 % of tot	1.8%	2.9%	0.4%	0.3%	2.4%
	Formal employment	1,249	1,249	0	n.a.	n.a.
	Informal employment	53,369	48,507	4,862	n.a.	n.a.
Mining and quarrying (2018)	Total	55,768	53,387	2,381	647	55,121
	2018 % of tot	1.8%	3.1%	0.2%	0.1%	2.4%

Source: NISR (2018a, 2018b – based on the Labour Force Survey)

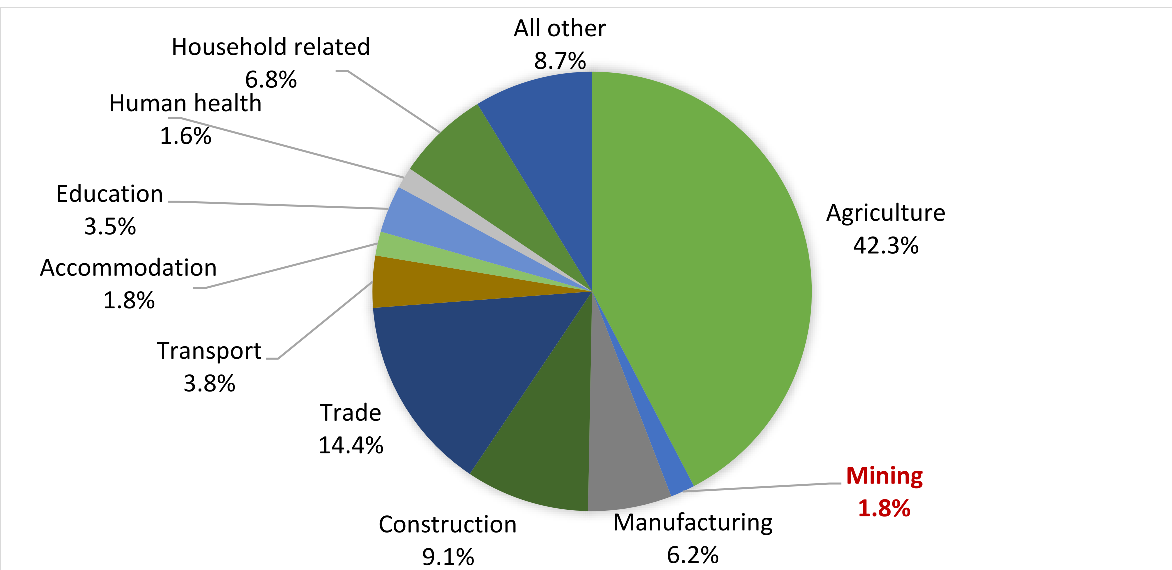

Figure 5: Distribution of employment in 2018

NISR (2018b)

Examples of artisanal mining in Ngororero District, Gatumba mining site
Photos: James Blignaut (2016)

This low number of formally employed is a result of the fact that the mining sector is characterised by artisanal small-scale mining (ASM). One of the key elements of artisanal mining is the shared role the sector is playing with respect to income generation with agriculture. In 2018, for example, 21,200 (or 40%) of the 53,300 people informally engaged in mining were also active in subsistence agriculture. This highlights the potential conflict between mining and agriculture, see also Appendix 4.

Table 3: Employment in the formal mining sector: According to IBES

	2015			2016		
	Males	Females	Total	Males	Females	Total
Total	128,681	54,986	183,667	147,719	68,806	216,525
Mining and quarrying (total)	4,069	660	4,729	4,482	432	4,914
Mining and quarrying (as % of the total)	3.2%	1.2%	2.6%	3.0%	0.6%	2.3%

Source: NISR (2017, 2018c – based on the Integrated Business Enterprise Survey)

The co-existence of mining and agriculture: Ngororero District, Gatumba mining site
Photos: James Blignaut (2016)

2.2 Mineral accounts for the 3T's: Materials and methods

2.2.1 Physical flow accounts

Picture of a tagged bag of mineral under the iTSCi system

Rwanda, as a member of the ITRI Tin Supply Chain Initiative (iTSCi Programme - https://www.itsci.org/), is committed to address conflict mineral concerns and is part of the International Conference on Great Lakes Region (ICGLR)'s regional initiative against the illegal exploitation of natural resources. The Programme establishes traceability in the upstream mineral chain for cassiterite, columbo-tantalite and wolframite. This is an inter-Governmental initiative involving the Governments of the Democratic Republic of Congo (DRC), Rwanda and other Great Lakes Region countries and their field agents. iTSCi through PACT NGO assists companies to establish due diligence through regular independent risk assessments and audits. The Programme supports the practical implementation of the Organization for Economic Cooperation and Development's (OECD) Due Diligence Guidance for Responsible Supply Chains, by allowing companies to source metals responsibly.

As part of this traceability process, iTSCi in conjunction with the RMB, ensures that all production output is tagged and captured within a database. Each batch of tagged production is tracked throughout its journey of production, processes, export and sale. This provides a very good basis for the generation of quality data with respect to the physical volume of production. The quality of the data can be improved through an electronic and real time data capturing, storage and management facility (see also Chapter 4).

In 2011 the Geology and Mining Department (GMD) was established. In July 2016 the GMD was transformed and became the RMB. Due to the establishment of the Department in 2011, and the fluid transition between the GMD and the RMB, the data provided herein commences in 2012. The physical flow data reported on here comprises:

1. the production data at mine site that mining operators sold to mining traders;
2. the volume of minerals that mining traders are processing; and
3. the export volume by mining traders.

From the data reported on here one unique characteristic of the Rwandan mining sector is highlighted. This is the distinction between mining operators and mining traders. While there are 67 licensed mineral traders, the sector is dominated by about five large trading companies. The accounts therefore differentiate between mining operators and mining traders, yet fully acknowledging the fact that the sector is both vertically and horizontally integrated. The production of the mining operators and their sales acts as the input or purchase of the traders.

2.2.2 Monetary flow accounts

One of the objectives of the monetary accounts is to generate consistent and comparable datasets for understanding trends in and contributions by the natural resource sector to economic development. One subset thereof linked to minerals accounts is the compilation the resource rents. Natural resource rents are a measure of the scarcity value of extractive resources such as minerals and is calculated as the surplus value after all costs, including normal profits have been accounted for (Blignaut and Hassan 2001 and 2002). The rent is therefore the difference between the turnover of the commodity (price multiplied by quality) and the cost of extraction, production and operation as well as the cost of capital and normal profits.

A positive resource rent is the return realised over and above all financial and economic costs, or stated differently, the surplus return above normal returns (the returns earned by other firms on average over time (SEEA 2014:152). This positive difference could be provided by either i) a high unit cost (due to increased scarcity of the resource), ii) high production or sale volumes relative to the cost of production due to system-wide efficiencies, iii) low production costs (due to one or other competitive advantage), iv) ease of access and high/or high ore quality, or v) a combination of the above. A negative rent would imply the opposite of these five factors. It should be noted that the impact of environmental externalities (or the value of the environmental costs) are not considered within the rent calculation and should be added to get a comprehensive and true value of the rent. Only the financial and not the broader social cost is therefore assessed. Chapter 3, however, does reflect on some of the environmental externalities concerned.

The calculation of resource rents in this report are based on the following principles and sources of data:

1. Volumetric data:
    a. The physical accounts provide the basis of the volumetric production and trade data, including exports.
2. Turnover:
    a. Mining operators:
        i. The production data from the physical accounts were multiplied by a unit price. The unit price of the sales was estimated using a sample of five trades per month for each of the large traders.
        The data quality can be improved through an electronic data capturing, storing and management system. See also Chapter 4.
    b. Mining traders:
        i. The turnover for the traders is provided by the value of the published export data. The unit price of their sales was estimated as the export value divided by the export volume as per the physical accounts.
        The quality of the data is high since both the export volume and the export sales are well captured and recorded.

    There is therefore not a standardised or uniform price series to estimate the turnover values for the mining operators and traders, and this is something to consider in future and to improve on, see also Chapter 4. The data can be improved through an electronic and online data capturing, storing and management system.

3. The cost of production:
    a. For both operators and traders, the cost of production was derived from a combination of the turnover data and the published sector-wide expenditure data as per the 2015 IBES of the NISR (NISR 2017).
    In this case the quality of the data can also be improved through an electronic data capturing, storing and management system and the collaboration between NISR and the RMB (see also Chapter 4).

b. The relative (or proportionate) expenditure value to income for both the operators and traders as per the IBES were used to estimate the distribution of the extraction, production and operating cost of the mining operators and traders respectively – see also the adjacent box.

> **The use of IBES in estimating the expenditure profile for the mining sector:**
> IBES is the Integrated Business Enterprises survey of the National Institute of Statistics in Rwanda (NISR). The NISR annually surveys a sample of companies in all economic sectors to, among others, determine the expenditure and income structures of all the economic sectors. Companies in both mining and that of mineral trade is surveyed based on a random and statistically significant sample
>
> This provides primary data with respect to the income and expenditure structure of all the economic sectors up to a 4-digit ISIC code level. This is also true for both mining operators and traders in mining commodities.
>
> This structure is used to determine the proportion of each expenditure item, such as intermediate consumption, to total expenditure and total sales. These proportions have been applied to the estimated turnover levels to estimate the level of each cost item.

c. The proportion derived in 3b was then applied to the actual production value (see 2 above), to estimate the sector-wide extraction, production and operating cost. While this system is imperfect, since the IBES data covers all mining sectors not just the 3T's, and it does not disaggregate among the 3T's, it provides a reasonable estimate of the expenditure value. One disadvantage though, and hence a specific recommendation in Chapter 4 in this regard, is the availability of only one suitable IBES, namely for 2015. The reason being that NISR commenced with IBES in 2015 and has changed its sampling methodology to 2016, with 2015 including more companies and was thus considered superior. This assumes that the ratio between income and expenditure among all the years are constant and can be proxied by this number.

d. To this cost (3c) the normal, to be expected, industry-wide profit is added as a proxy to the cost of capital. This is estimated as:
   - the social discount rate (SDR) (as published by the National Bank of Rwanda (BNR)) multiplied by
   - the value of the consumption of fixed capital, multiplied by,
   - the weighted average permitted lifespan of fixed capital for depreciation purposes.

   Ideally IBES should capture the data to enable a more accurate estimation of the opportunity cost of capital.

   This approach is likely to underestimate the size of the opportunity cost of capital, but it is considered better than the alternative. The alternative being the product of the SDR and the estimate of the non-current asset holding for mining and quarrying according to IBES. This method is likely to over-estimate the opportunity cost of capital as the non-current asset holding is reflected at replacement value, and it is for the entire sector and not just for the 3T's. Under-estimating this value increases the size of the resource rent. The resource rent is therefore likely to be marginally too high.

4. The resource rent is estimated as the value of the turnover (item 2) less the value of all the cost items inclusive of a normal profit (item 3).

2.3 Physical accounts

The physical accounts for the 3T's are a result of data collection and analysis for the years 2012-2016 as stated above with iTSCi and the RMB being the sole provider of the data based on data collected at the mine sites, trading and export operations.

Table 4: Physical flow accounts for Cassiterite: 2012-2016

	Source	Units	2012	2013	2014	2015	2016
Mining operations							
Tagged production	iTSCi	Tonnes	3,671	6,112	7,137	4,714	2,024
Trading operations							
Tagged purchases	iTSCi	Tonnes	3,671	6,112	7,137	4,714	2,024
Less: Waste or losses during processing by traders	Calc	Tonnes	-910	1,318	1,232	1,509	-1,264
Equal: Processed and tagged production	iTSCi	Tonnes	4,581	4,795	5,905	3,205	3,288
Change in inventory	Calc	Tonnes	-56	-101	-49	-640	-262
Equal: Marketed production (exports)	RMB	Tonnes	4,637	4,895	5,954	3,846	3,550
Average export price	Table 7	US$/tonne	11,408	12,476	12,084	8,910	9,805

Sources: Compiled by James Blignaut, Peter Katanisa, Aussi Sayinzoga, Swaib Munyawera, Jean Pierre Bizimana and Francois Naramabuye based on the sources indicated in the table.

The physical flow accounts for cassiterite (Table 4) shows a 67% increase in tagged production volumes, that is the volume of production that has received a tag as discussed in Section 2.2.1) from 2012 to 2013, 17% increase in 2014 and then drops by 34% and 57% in 2015 and 2016 respectively. These are total computations for each year as recorded in iTSCi databases derived from the mine logbooks. The negative change in inventory is indicative on the continuous reduction of mineral stock on site.

The tagged production volumes are direct purchases by the mining traders before any processing or added value is done as indicated in Table 4. After processing, total volumes tagged are recorded. Results indicate increased volumes after processing in 2012 and 2016 which could be a result of inventories carried on from the previous years or discrepancies in data capture otherwise expected is a loss in volumes after processing as a result of waste repositories during processing by Traders as it is the case for 2013, 2014 and 2015 as shown as the processed and tagged production item in Table 4.

Export volumes is equal to marketed production. Results show an increase in volumes in various years, 1% in 2012 and 2014, 2% in 2013, 20% and 8% in 2015 and 2016 respectively. Under normal circumstances the volume exported should be less than purchases because of volumetric losses during processing and refining whereby the grade of the product is increased. In cases where this is not the case, it is due to changes in inventories. Such changes could be as a result of changes in international market prices whereby companies might opt to stockpile their resources under conditions of low prices with the intention to sell it later, or it could be attributed to discrepancies in data capture at different levels. As noted also in Chapter 4, improving the data capturing, storing and management system is important to also be able to understand the changes in inventories better.

Table 5: Physical flow accounts for Coltan: 2012-2016

	Source	Units	2012	2013	2014	2015	2016
Mining operations							
Tagged production	ITRI	Tonnes	968	1,924	2,098	1,332	2,554
Trading operations							
Tagged purchases	ITRI	Tonnes	968	1,924	2,098	1,332	2,554
Less: Waste or losses during processing by traders	Calc	Tonnes	26	-122	-187	-258	1,378
Equal: Processed and tagged production	ITRI	Tonnes	942	2,047	2,285	1,590	1,176
Change in inventory	Calc	Tonnes	-202	-419	-18	-62	-94
Equal: Marketed production (exports)	RMB	Tonnes	1,145	2,466	2,303	1,652	1,270
Average export price	Table 8	US$/tonne	49,718	54,570	45,507	40,080	31,295

Sources: Compiled by James Blignaut, Peter Katanisa, Aussi Sayinzoga, Swaib Munyawera, Jean Pierre Bizimana and Francois Naramabuye based on the sources indicated in the table.

The physical flow accounts for coltan (Table 5) also reports total production volumes in tonnes as extracted from ITRI database with the totals in the tagged production row for the years 2012 to 2016. It indicates an increasing trend in volumes at production from 2012 to 2014, which drops by 9% in 2015 and again picked up in 2016.

At the trading sites, we also see increased total volumes in 2013 to 2015 when we compare total tagged purchases with the processed tagged production whereas 2016 shows much waste or losses during the processing by traders as extracted from ITRI reports.

Across the years, export levels also indicate increased volumes when compared with the processed volumes recorded. This does raise the question where the additional volume of exported material comes from but might be attributed to either a change in inventories, or inconsistences with respect to the data capturing process. This necessitates the consideration of an integrated and electronic data management and archiving system. See Chapter 4 in this regard.

Table 6: Physical flow accounts for Wolfram: 2012-2016

	Source	Units	2012	2013	2014	2015	2016
		Mining operations					
Tagged production	ITRI	Tonnes	1,771	2,264	2,535	2,169	1,498
		Trading operations					
Tagged purchases	ITRI	Tonnes	1,771	2,264	2,535	2,169	1,498
Less: Waste or losses during processing by traders	Calc	Tonnes	187	-6	476	846	-141
Equal: Processed and tagged production	ITRI	Tonnes	1,585	2,270	2,059	1,323	1,639
Change in inventory	Calc	Tonnes	-166	52	-156	-461	-77
Equal: Marketed production (exports)	RMB	Tonnes	1,751	2,218	2,214	1,784	1,716
Average export price	Table 9	US$/tonne	15,002	13,550	12,008	9,719	6,920

Sources: Compiled by James Blignaut, Peter Katanisa, Aussi Sayinzoga, Swaib Munyawera, Jean Pierre Bizimana and Francois Naramabuye based on the sources indicated in the table.

The physical flow accounts for wolfram (Table 6) also report total volumes like the previous two minerals. The changes in the production and exported volumes are provided in Figure 6. This indicates that cassiterite production and exports peaked in 2014 and declined thereafter. Production and exports with respect to the other two minerals have not fluctuated much over the period.

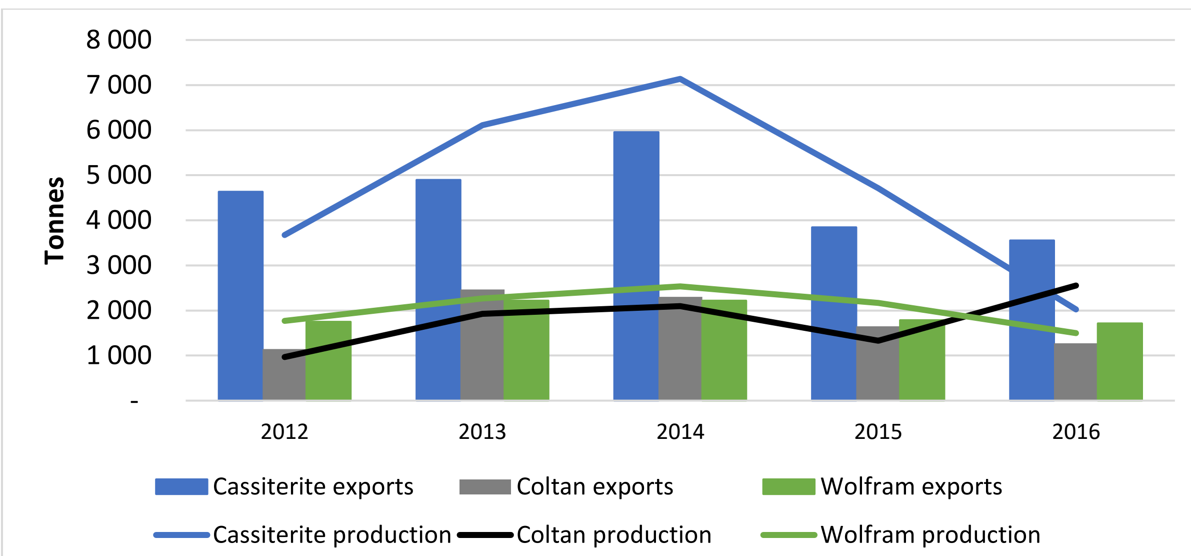

Figure 6: Production and exports of the 3T's in Rwanda: 2012 - 2016

2.4 Monetary flow accounts

The monetary flow accounts of the 3T's for 2012 – 2016 for both mining operations and traders are provided below. They have been derived based on the data and methods discussed in Section 2.2, using also the volumetric data as per Section 2.3.

The monetary flow accounts for cassiterite are provided in Table 7. The analysis of the trends will be discussed in Section 2.5. In 2016 mining operators produced 2,024 tonnes of Cassiterite. This was sold to traders at an average price of US$7,573/tonne which yielded a total sales value of US$15.3 million for the sector. Based on the IBES expenditure to income ratio for mining operators, the estimated cost of production amounts to approximately US$15.6 million, leaving a net loss before taking the opportunity cost of capital into account of US$300,000. The estimated opportunity cost of capital of US$270,000 (1.7% of the total cost) should be added to reflect the opportunity cost of capital. The total financial and economic cost is thus estimated to be US$15.9 million resulting in a resource rent of -US$540,000.

With respect to the traders, 3,550 tonnes of Cassiterite were exported in 2016 yielding an export earnings of US$34.8 million at an average unit price of US$9,805/tonne. Based on the IBES expenditure to income ratio for mining traders, the total financial cost for the sector is estimated US$35.7milion. Adding the opportunity cost of capital of approximately US$335,000 yields a resource rent of almost -US$1.2 million.

Table 7: Monetary flow accounts for Cassiterite: 2012-2016

		Source	Units	2012	2013	2014	2015	2016
	Mining operations							
1	Production	Table 4	Tonnes	3,671	6,112	7,137	4,714	2,024
2	Average unit production price	Calc	US$/tonne	9,214	10,196	10,101	7,003	7,573
3	Sales	Calc	US$	33,819,884	62,321,073	72,098,392	33,014,920	15,328,447
4	Less: Intermediate consumption	Based on IBES	US$	28,602,849	52,707,461	60,976,537	27,922,058	12,963,890
5	Less: Other operating and overhead costs	Based on IBES	US$	5,224,161	9,626,742	11,137,045	5,099,818	2,367,787
6	Less: Consumption of capital	Based on IBES	US$	575,398	1,060,305	1,226,652	561,702	260,792
7	Less: Opportunity cost of capital	Calc	US$	650,199	1,113,320	1,312,518	589,787	273,831
8	Equal: Resource rent	Calc	US$	-1,232,722	-2,186,756	-554,360	-1,158,445	-537,853
9	Unit rent	Calc	US$/tonne	-336	-358	-358	-246	-266
	Trading operations							
10	Production (exports)	Table 4	Tonnes	4,637	4,895	5,954	3,846	3,550
11	Average unit export price	Calc	US$/tonne	11,408	12,476	12,084	8,910	9,805
12	Sales (exports)	RMB	US$	52,896,906	61,074,479	71,945,617	34,263,244	34,807,904
13	Less: Purchase of raw material	IBES	US$	45,207,900	52,196,795	61,487,723	29,282,796	29,748,285

14	Less: Other operating and overhead costs	IBES	US$	8,582,741	9,909,586	11,673,473	5,559,353	5,647,726
15	Less: Consumption of capital	IBES	US$	484,942	559,911	659,574	314,114	319,108
16	Less: Opportunity cost of capital	Calc	US$	547,984	587,907	705,744	329,820	335,063
17	Equal: Resource rent	Calc	US$	-1,926,661	-2,179,720	-2,580,897	-1,222,839	-1,242,278
18	Unit rent	Calc	US$/tonne	-416	-445	-433	-318	-350
19	Royalty payments	Calc	US$	0	1,221,490	2,877,825	1,370,530	1,392,316

Sources: Compiled by James Blignaut, Peter Katanisa, Aussi Sayinzoga, Swaib Munyawera, Jean Pierre Bizimana and Francois Naramabuye based on the sources indicated in the table.

Notes:

1. Total mineral volumes in tonnes produced at mine site extracted from the physical flow accounts
2. The average price paid by traders to miners based on a sample of five trades per month for each of the five largest traders. This method had to be adopted since there is no centralised time series available.
3. Calculated based on the average price per tonne multiplied by the total production
4. Based on the proportion of the sum of i) the purchases of goods for resale, ii) purchases of raw materials, iii) fuel, and iv) administrative and overhead costs, to the total cost as per IBES
5. Based on the proportion of the sum of i) rent of land/buildings paid, ii) other goods and services purchased, iii) wages & salaries paid, iv) interests paid, v) business licenses, vi) rates and fees payable to government and all other costs, losses, provisions, to the total cost as per IBES
6. Based on the proportion of depreciation allowances for the year on fixed assets to the total cost as per IBES
7. The social discount rate (SDR) as per the National Bank of Rwanda multiplied by the consumption of capital (depreciation) multiplied by the permitted average lifespan of fixed capital for depreciation purposes.
8. Total sales minus the total of intermediate consumption, operating and overhead costs, consumption of capital and the opportunity cost of capital.
9. Resource rent divided by total production volumes (Tonnes).
10. Total mineral volumes in tonnes exported extracted from the physical flow accounts.
11. Total export sales divided by total export volumes.
12. Total export sales.
13. Based on the proportion of purchases of goods for resale including the intermediate consumption, to the total cost as per IBES.
14. Based on the proportion of the sum of i) rent of land/buildings paid, ii) other goods and services purchased, iii) wages & salaries paid, iv) interests paid, v) business licenses, vi) rates and fees payable to government and all other costs, losses, provisions, to the total cost as per IBES.
15. Based on the proportion of depreciation allowances for the year on fixed assets to the total cost as per IBES
16. The SDR multiplied by the consumption of fixed capital multiplied by the permitted average lifespan of fixed capital for depreciation purposes.
17. Total sales (exports) minus the sum of intermediate consumption, operating and overhead costs, consumption of capital and the opportunity cost of capital.
18. Resource rent divided by total export volumes.
19. The royalty payment is based on a tax of 4% on the export value of the minerals.

The monetary flow accounts for coltan are provided in Table 8. Mining operators produced 2,554 tonnes of coltan in 2016 which was sold to traders at an average price of US$35,081/tonne and yielded a total sales value of US$89.6 million for the sector. Based on the IBES expenditure to income ratio for mining operators, the estimated cost of production amounts to approximately US$91.1 million, yielding a financial loss to the sector of about US$1.6 million. The estimated opportunity cost of capital of US$1.6 million should be added to reflect the opportunity cost of capital. The total financial and economic cost is thus estimated to be US$92.7 million resulting in a resource rent of -US$3.2 million.

With respect to the traders, 1,270 tonnes of coltan were exported in 2016 yielding an export earnings of US$39.7 million at an average unit price of US$31,295/tonne. Based on the IBES expenditure to income ratio for mining traders the total financial cost for the sector is estimated US$40.8 million. Adding the opportunity cost of capital of US$380,000 yields a resource rent of almost -US$1.4 million.

The monetary flow accounts for wolfram are in Table 9. Mining operators produced 1,498 tonnes of Wolfram in 2016. This was sold to traders at an average price of US$5,573/tonne and yielded a total sales value of US$8.3 million for the sector. Based on the IBES expenditure to income ratio for mining operators, the estimated cost of production amounts to approximately US$8.5 million, a loss of US$200,000. The estimated opportunity cost of capital of US$150,000 should be added to reflect the total financial and economic cost. This is thus estimated to be US$8.6 million resulting in a resource rent of -US$300,000. With respect to the traders, 1,716 tonnes of wolfram were exported in 2016 yielding export earnings of US$11.9 million at an average unit price of US$6,920/tonne. Based on the IBES expenditure to income ratio for all mining traders the total financial cost for the sector is estimated US$12.2 million. Adding the opportunity cost of capital of US$110,000 yields a resource rent of almost -US$420,000.

Table 8: Monetary flow accounts for Coltan: 2012-2016*

		Source	Units	2012	2013	2014	2015	2016
	Mining operations							
1	Production	Table 5	Tonnes	968	1,924	2,098	1,332	2,554
2	Average unit production price	Calc	US$/tonne	49,840	56,141	44,662	42,300	35,081
3	Sales	Calc	US$	48,239,518	108,036,966	93,678,385	56,344,093	89,582,145
4	Less: Intermediate consumption	Based on IBES	US$	40,798,119	91,371,247	79,227,613	47,652,487	75,763,257
5	Less: Other operating and overhead costs	Based on IBES	US$	7,451,563	16,688,480	14,470,509	8,703,477	13,837,762
6	Less: Consumption of capital	Based on IBES	US$	820,727	1,838,096	1,593,805	958,615	1,524,114
7	Less: Opportunity cost of capital	Calc	US$	927,422	1,930,001	1,705,372	1,006,546	1,600,319
8	Equal: Resource rent	Calc	US$	-1,758,312	-790,859	-3,318,914	-1,977,032	-3,143,307
9	Unit rent	Calc	US$/tonne	-1,817	-1,970	-1,582	-1,484	-1,231
	Trading operations							
10	Production (exports)	Table 5	Tonnes	1,145	2,466	2,303	1,652	1,270
11	Average unit export price	Calc	US$/tonne	49 718	54 570	45,507	40 080	31,295
12	Sales (exports)	RMB	US$	56,911,605	134,571,614	104,780,331	66,200,323	39,742,507

13	Less: Purchase of raw material	IBES	US$	48,639,029	115,010,509	89,549,637	56,577,555	33,965,602
14	Less: Other operating and overhead costs	IBES	US$	9,234,143	21,834,799	17,001,041	10,741,275	6,448,386
15	Less: Consumption of capital	IBES	US$	521,747	1 233 709	960,592	606,903	364,347
16	Less: Opportunity cost of capital	Calc	US$	589,574	1,295,395	1,027,834	637,248	382,564
17	Equal: Resource rent	Calc	US$	-2,072,888	-4,802,798	-3,758,773	-2,362,659	-1,418,392
18	Unit rent	Calc	US$/tonne	-1,811	-1,948	-1,632	-1,430	-1,117
19	Royalty payments	Calc	US$	0	2,691,432	4,191,213	2,648,013	1,589,700

Sources: Compiled by James Blignaut, Peter Katanisa, Aussi Sayinzoga, Swaib Munyawera, Jean Pierre Bizimana and Francois Naramabuye based on the sources indicated in the table.
* See Table 7 for explanatory notes on the definitions of the table entries.

Table 9: Monetary flow accounts for Wolfram: 2012-2016*

		Source	Units	2012	2013	2014	2015	2016
	Mining operations							
1	Production	Table 6	Tonnes	1,771	2,264	2,535	2,169	1,498
2	Average unit production price	Calc	US$/tonne	12,738	11,327	10,091	7,378	5,573
3	Sales	Calc	US$	22,562,072	25,647,295	25,579,870	16,004,829	8,348,512
4	Less: Intermediate consumption	Based on IBES	US$	19,081,660	21,690,959	21,633,934	13,535,934	7,060,675
5	Less: Other operating and overhead costs	Based on IBES	US$	3,485,165	3,961,740	3,951,325	2,472,267	1,289,595
6	Less: Consumption of capital	Based on IBES	US$	383,862	436,353	435,205	272,300	142,038
7	Less: Opportunity cost of capital	Calc	US$	433,764	458,170	465,670	285,915	149,140
8	Equal: Resource rent	Calc	US$	-822,379	-899,926	-906,264	-561,586	-292,937
9	Unit rent	Calc	US$/tonne	-464	-397	-358	-259	-196
	Trading operations							
10	Production (exports)	Table 6	Tonnes	1,751	2,218	2,214	1,784	1,716
11	Average unit export price	Calc	US$/tonne	15,002	13,550	12,008	9,719	6,920
12	Sales (exports)	RMB	US$	26,262,462	30,053,782	26,592,318	17,343,129	11,873,683
13	Less: Purchase of raw material	IBES	US$	22,444,994	25,685,215	22,726,903	14,822,160	10,147,744
14	Less: Other operating and overhead costs	IBES	US$	4,261,193	4,876,350	4,314,713	2,813,994	1,926,554
15	Less: Consumption of capital	IBES	US$	240,766	275,523	243,790	158,996	108,854
16	Less: Opportunity cost of capital	Calc	US$	272,065	289,300	260,855	166,946	114,297
17	Equal: Resource rent	Calc	US$	-956,556	-1,072,606	-953,943	-618,968	-423,766
18	Unit rent	Calc	US$/tonne	-546	-484	-431	-347	-247

19	Royalty payments	Calc	US$	0	601,076	1,063,693	693,725	474,947

Sources Compiled by James Blignaut, Peter Katanisa, Aussi Sayinzoga, Swaib Munyawera, Jean Pierre Bizimana and Francois Naramabuye based on the sources indicated in the table.
* See Table 7 for explanatory notes for the definitions on the table entries.

2.5 Mineral flow accounts for Rwanda: An analytical comparison

2.5.1 Production and exports

The production value (for the mining operators) and the export value (for mining traders) are based on the product of the unit price and the volume either sold (from operators to traders) or exported by the traders. The volume traded with respect to production and exports for the 3T's for both production and export is provided in Figure 7. The volume traded peaked in 2014, but thereafter declined in all cases except for coltan traders. This reduction in volume traded is as a result of the decline in unit prices (Figure 8). The increase in the production price for coltan explains the increase in the sales of coltan by the mining operators. As a result of these declining trends, the value of sales, with the exception of coltan, declined over the five years examined (Figure 9).

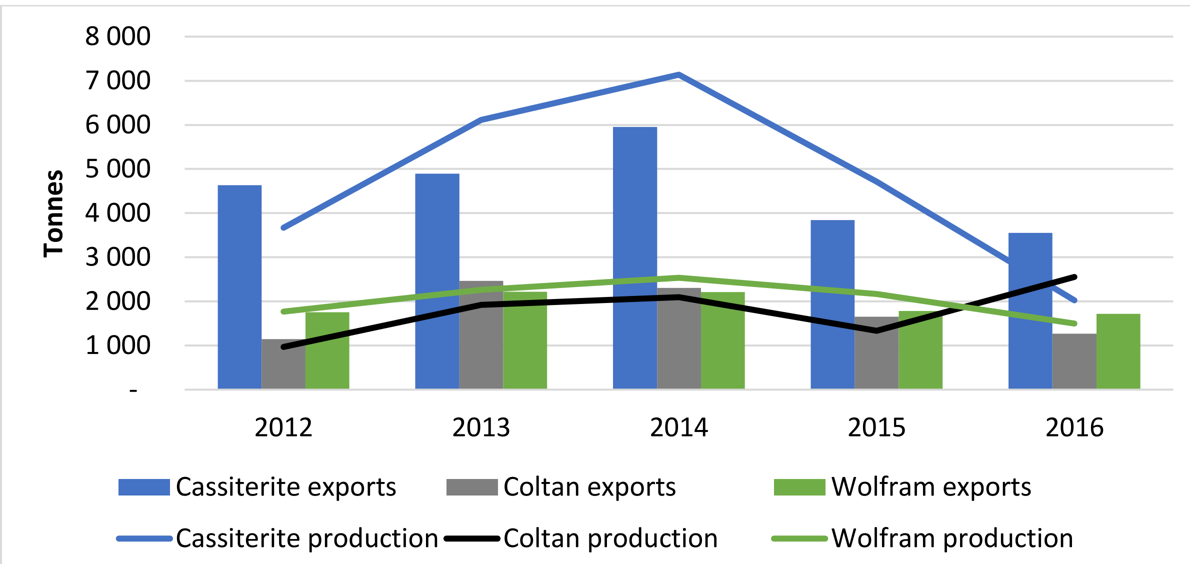

Figure 7: Production and exports of the 3T's for Rwanda: 2012-2016

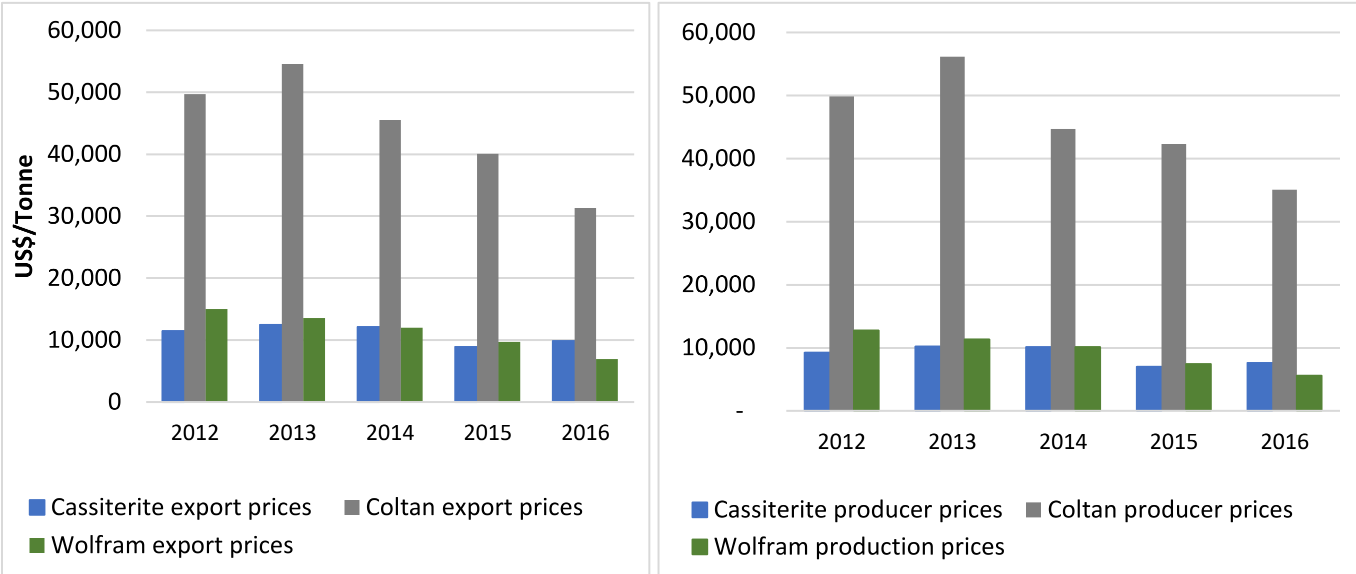

Figure 8: Producer and export unit prices of the 3T's for Rwanda: 2012-2016

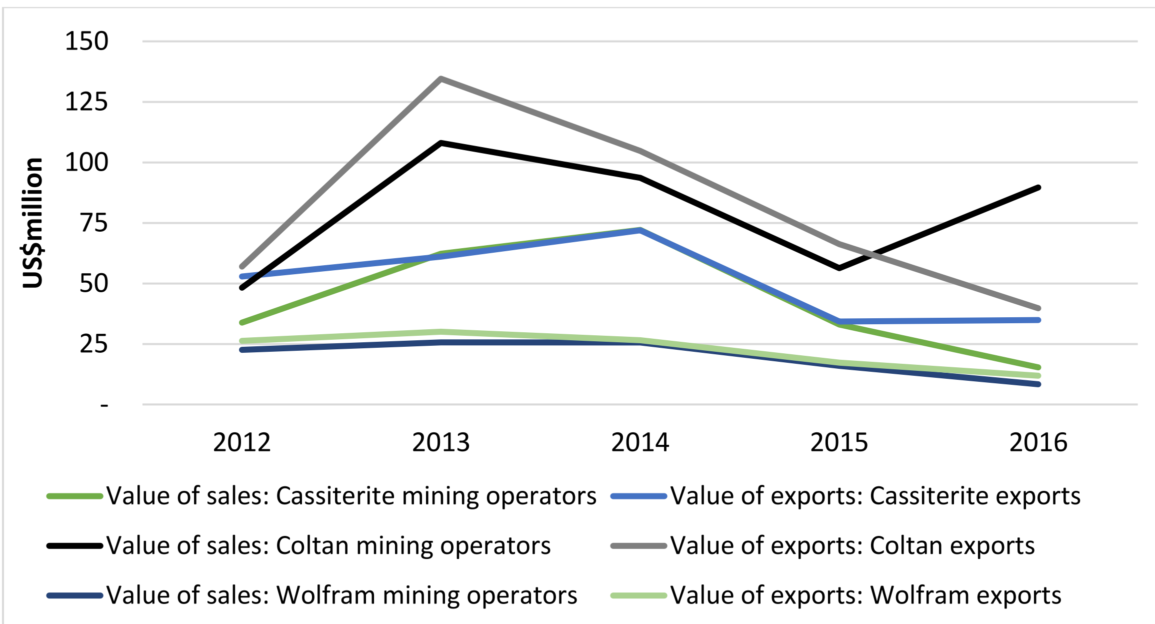

Figure 9: The value of production and exports for the 3T's in Rwanda: 2012 - 2016

2.5.2 Mineral exports prices and international metal prices: a comparison

As mentioned earlier, Rwanda trade in minerals (cassiterite, coltan and wolfram) that is used to extract the metals (tin, tantalum and tungsten) from. The unit export prices (US$/tonne) of the minerals and the international metal prices are provided in Table 10 and Figure 10. While the underlying relationship between the unit mineral and metal prices is constant, except for the relationship between wolfram and tungsten that is declining. The unit export price of cassiterite is about 55% of that of tin. The unit export price of coltan, however, is only about 23% that of tantalum, a noteworthy discrepancy given the high unit values of tantalum. The unit export price of wolfram is even lower at about 18% that of tungsten, and declining. These small and declining shares also explain, in part, the decline in the share of the export revenue from the minerals under consideration.

Table 10: Comparison between the unit export prices of the minerals and the international metal prices: US$/tonne

	2012	2013	2014	2015	2016	Sources
Cassiterite	11,408	12,476	12,084	8,910	9,805	Table 7
Tin	21,109	22,281	21,898	16,066	17,933	https://www.metalary.com/tin-price/
Coltan	49,718	54,570	45,507	40,080	31,295	Table 8
Tantalum	292,000	317,000	152,000	174,000	134,000	https://www.metalary.com/tantalum-price/
Wolfram	15,002	13,550	12,008	9,719	6,920	Table 9
Tungsten	56,700	46,600	43,840	40,320	38,150	https://www.metalary.com/tungsten-price/

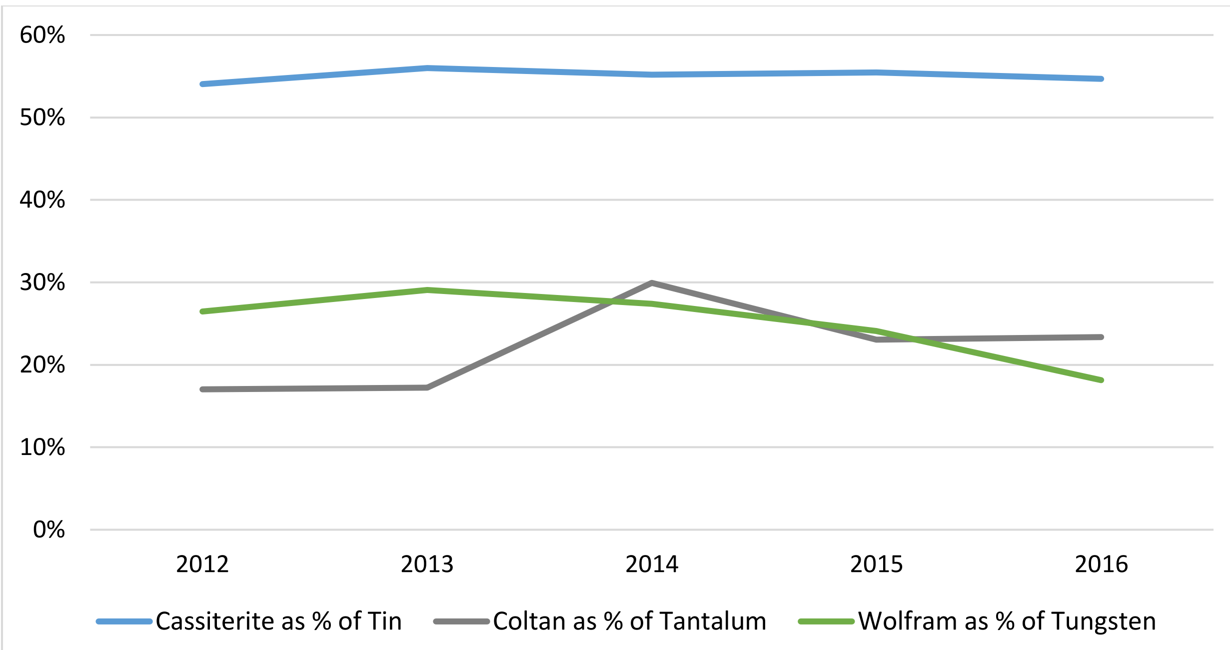

Figure 10: Export prices of minerals as % of international metal prices: 2012 - 2016

2.5.3 Resource rents

When calculating the resource rents, the results indicate negative rents (Figure 11). The negative resource rents either implies resource abundance (absence of resource scarcity), or it is a clear indicator of an illiquid or cash-strapped and lossmaking sector that operates at sub-optimal levels. What is true is that the mining sector in Rwanda is seriously handicapped by its lack in liquidity. This liquidity constraint hampers its ability to honour its commitments with respect to safety, health and the environment, among others.

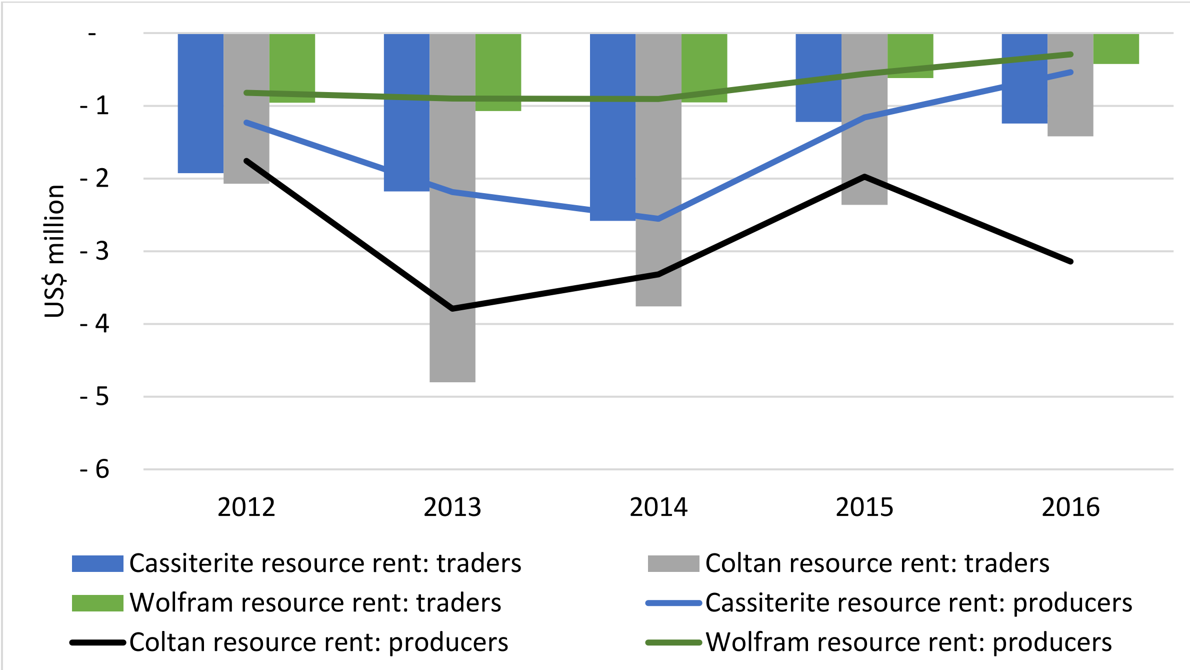

Figure 11: Resource rents of the 3T's for Rwanda: 2012-2016

The negative rents are the result of:

1. unit prices that are too low to ensure profitability;
2. high system-wide inefficiencies leading to too low production;
3. production costs that are too high with respect to the level of production;
4. low quality or accessibility of the resource; or
5. a combination of the above.

These five factors will briefly be discussed to ascertain which of them, or combination thereof, are most likely to be the driver(s) behind the negative rents.

Unit prices

The resource rent for all three minerals for both the operators and the traders for 2016 was -US$7,06 million. If the unit price received by the mining operators is increased by 3,5%, and the unit export price by 3,6%, then the negative resource rent will turn zero. This, however, should be considered against the backdrop of what has been stated earlier, namely that given the method used to estimate the opportunity cost of capital that the resource rents are probably overstated. Should the average unit price increase by, for example, 9% and 12% the resource rent will be approximately US$11 and US$17 million respectively (see Table 11), with coltan providing the bulk of the rent.

Table 11: Resource rent: sensitivity analysis for different unit prices: US$'000

	Sales: 2016	Production cost: 2016	Resource rent: 2016	Increase in the average unit price of the mineral			
				+3,5%	+6%	+9%	+12%
Cassiterite: Operators	15,328	15,866	-537	-1	381	841	1,301
Cassiterite: Traders	34,807	36,050	-1,242	-24	846	1,890	2,34
Coltan: Operators	89,582	92,725	-3,143	-7	2,231	4,919	7,606
Coltan: Traders	39,742	41,160	-1,418	-27	9669	2,158	3,350
Wolfram: Operators	8,348	8,641	-292	-1	207	458	708
Wolfram: Traders	11,873	12,297	-423	-8	288	644	1,001
Total	199,683	206,741	-7,058	-69	4,922	10,912	16,903

Production inefficiencies

Heizmann (2017), after considering the production efficiencies of three small-scale artisanal mining companies in Rwanda, concluded that the mineral recovery rates are on average 31%, but occasionally as low as 11%. This is reminiscent of the technology used and is a contributing factor to the low and negative resource rents. It is therefore a stated objective of the RMB to improve the recovery efficiencies and the technology used (RMB 2018a).

Production cost

Given the state of the sector, a reduction in expenditure is undesirable. On the contrary, more should be done with respect to the safety and health of mine workers, as well as environmental protection and the compensation of the mine workers themselves. As will be noted in Chapter 3, the sector is underinvesting in environmental, health and safety related aspects. So, if anything, the production cost is too low. Improving the rent can thus not be achieved through such a reduction.

Quality and accessibility of the ore

While the country is mountainous and the accessibility thereof through the road infrastructure is difficult, it cannot be a dominant reason for the negative resource rents. This is because most of the mines are located near villages due to the size of the country and the proximity of the mines. Heizmann (2017) has also indicated that the ore is of high quality, with concentrates of cassiterite, for example, up to 70% and even more in some cases.

Summary

Given this analysis it seems as if the dominant factors contributing to the negative resource rents are the low prices and the system-wide production inefficiencies. These matters must be addressed for the rents to turn positive; Chapter 4 suggests some recommendations. It is encouraging to note that only a small change in the unit prices could make a significant difference in the prospects of the mining sector.

2.5.4 Royalties and operational structure

Rwanda has a policy of capturing the mining royalty as 4% of the sales (export) value since August 2013 (Rwanda 2013b). This implies that, in total over all the years for all the 3T's, the GoR earned about

US$21 million. In contrast the resource rent was, however, -US$53 million. Traditionally the royalties are used to capture the resource rent and to re-invest in the economy to seek long-term sustainability.

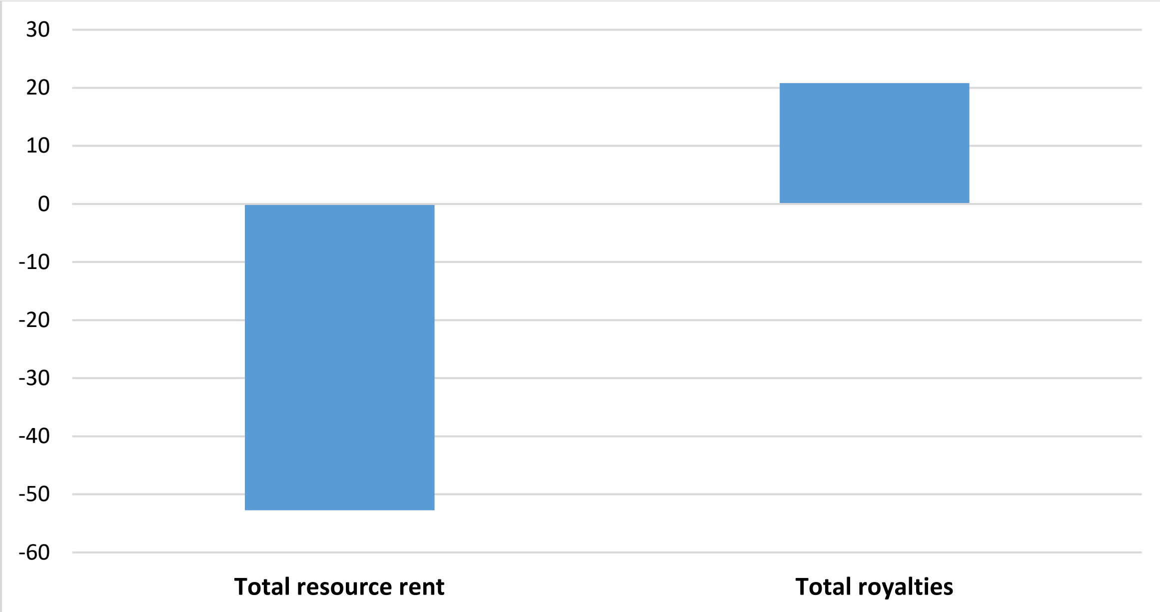

Figure 12: Total resource rents of the 3T's compared to royalties paid: August 2013-2016

The production cost structure for miners and traders (Figure 13) resemble each other. Mining operators' cost is dominated by intermediary expenses (82%), that comprise purchases of raw material from contractors and small artisanal miners (55.2%), and all other intermediate expenses (26.5%), followed by operating and overhead costs (15%). In comparison, the traders' main expenditure item is the purchase of raw material from the mining operators (83%). This is to be expected since the traders are buying the produce from the miners. Operating and overhead costs accounts for about 16% of the total cost.

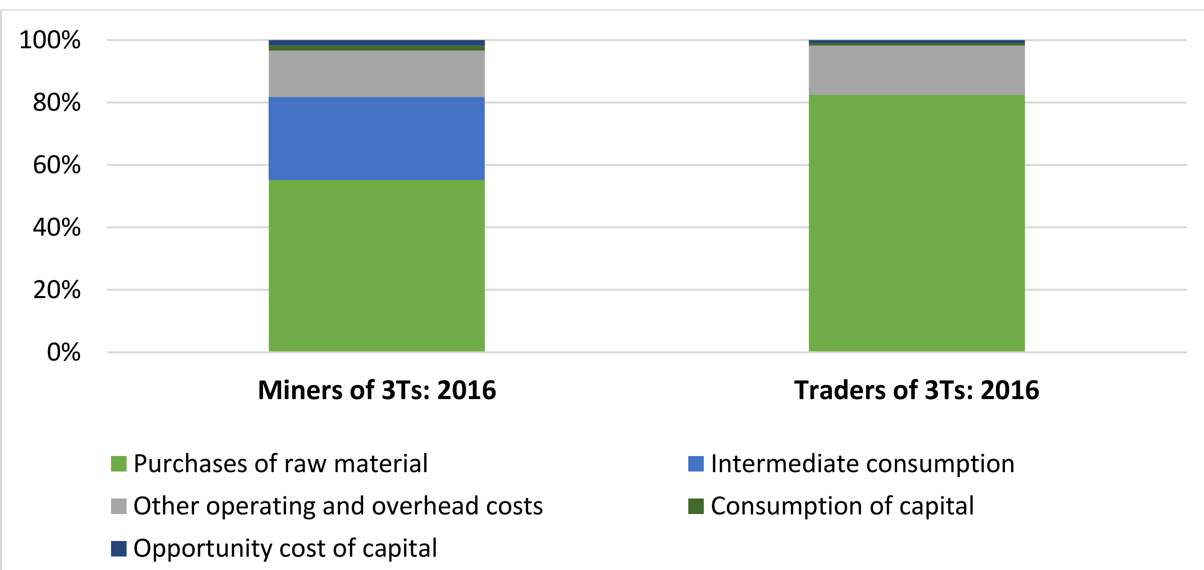

Figure 13: Composition of the cost structure for 3T traders: 2016

3 ENVIRONMENTAL IMPLICATIONS OF MINING IN RWANDA

3.1 Introduction

Mining activities, by its design, disturb and transform the natural environment. Such disturbance and transformation, in most instances, have a permanent and irreversible impact on ecosystem processes and functioning and the resulting stream of ecosystem goods and services flowing from the impacted site. This change in the flow of ecosystem goods and services varies, and quite significantly so, before, during, and after mining.

Before mining the flow of ecosystem goods and services would be largely dependent of the type of land-use, be it in its natural or pristine and untransformed state, or transformed through, for example, agriculture. During mining the main ecosystem services that are forthcoming from the site would be the mineral resources that are being extracted. After mining the flow of ecosystem goods and services will depend on the type and quality of post-mining rehabilitation and the land-use type towards which the land parcel has been exited to. Unfortunately, however, in addition to these there are also negative or detrimental environmental consequences of the mining activity. These include the loss of natural habitat, soil erosion, water pollution and detrimental impacts on human health, and even loss of life. The intensity and scope of the mining externalities are acerbated by Rwanda's and typography, see also Appendix 3.

As mentioned earlier, the compilation of the mineral resource flow accounts, both in terms of monetary and physical terms, only considers financial aspects and not any social and/or environmental impact. Here we therefore reflect briefly on this topic by considering the mining legislation in this respect and a brief overview of some of the environmental impacts of mining in Rwanda.

3.2 Mining legislation and policy: A summary

The government of Rwanda, through the RMB, has recognised the detrimental impact of mining on the environmental and on the quality of life of the people of Rwanda. In 2018 both the mining law (the Law on Mining and Quarry Operations, Law No 58/2018 of 13/08/2018; Rwanda 2018) and the draft mining policy (RMB 2018) was introduced. Herewith a brief summary therefore with respect to environmental considerations.

Law on Mining and Quarry Operations, Law No 58/2018 of 13/08/2018
Prior to the commencement of any operations, mining licence holders must submit to the competent authority a report on the study on environmental impact assessment (EIA) and social welfare approved by relevant public organ. During the various phases of mining, there are different requirements, such as:

Exploration:

- According to the Law the maximum area of exploration should not exceed the recommended size, and the maximum duration of exploration should not exceed the period specified in agreement with the regulator institution. In case of trenching and pitting, auguring and other forms of drilling, rehabilitation should be done as recommended in EIA. Time must be indicated as to when rehabilitation starts after exploration ends.

Operation:

- During the mining phase, minerals exploitation should be guided by an EIA with clear Social Impact Assessment (SIA), and adequate compensation for local communities. Minerals extraction should be done in designated areas and mining based on the type of minerals, land uses, and ecological sensitivity of mining areas. Wastes should be disposed in designated disposal sites. Appropriate technology must be used to increase efficiency, dust, and noise and vibration control to acceptable levels. Toxic by-products should be properly managed.

Post-mining:

- Disused mines should be rehabilitated according to EIA and EMP. Government should facilitate EIA and provide disaster vulnerability profiles for mine sites. Mine operators should be encouraged to operate as organized groups and assessed to ascertain capacity to mine i.e. skills, equipment and finances (MINIRENA 2017).

In addition to the above, License holders are required to:

- Rehabilitate damaged areas, reinstatement of boreholes and excavations, afforestation, removing buildings and levelling, of any part affected by exploration, mining or quarry operations basing on the environmental impact assessment and in compliance with the law on environment (Article 40).
- Have a rehabilitation plan which shows the planned activities and related budget. License holders remain liable for environmental protection until a final rehabilitation certificate is issued by the authority in charge of environmental protection (Article 41).
- Provide an environmental rehabilitation guarantee. The nature and amount of environment rehabilitation guarantee and as well as modalities for depositing it are determined by regulations of the competent authority (Article 42).
- Make sure that the mine is commissioned, maintained and decommissioned in a manner that does not compromise the health and safety of workers and other people, ensure that all persons working at the mine have the necessary skills, competence and resources to carry out their work safely and also ensure the safety of others. Where the authorized officer considers that the operations may compromise or endanger the health and safety of a person, that officer may make an urgent decision. Such a decision may require the identified danger to be rectified immediately or within a reasonable time or that the mining or quarry operations be suspended until the danger is rectified (Article 43).
- To have authorization of the Minister in charge of internal security before importation, manufacturing, transportation, trading, use of dynamites in mining and quarry operations, and will require a recommendation of the competent authority (Article 44)

The draft mining policy (RMB 2018)

The mining policy proposes two main objectives with respect to environmental sustainability and social support, namely:

- The reduction of the negative environmental impact of mining and related activities and the transparent and equitable exploitation of mineral resources to underpin inclusive sustainable growth and socio-economic development; and
- To promote green mining practices by considering the economy, the community, the environment, efficiency and safety.

These objectives, according to the policy, are to address some of the main consequences of mining, namely:

- Changes to surface and ground water flows and levels;
- Damage to soils including salination, acidification, pollution and compaction or loss of soil structure;
- Dust or noise nuisance, vibration and a reduction of visual landscape values;
- Gaseous emissions from mineral processing, methane emissions from mine openings, fumes from coal seam fires where it is used to provide energy;
- Danger of sudden failure of engineered containment structures such as tailings dam embankments, settling and holding ponds, resulting in release of high concentration/ high volume contaminants;
- Acid mine drainage (tailings, ore and waste dumps, and old mining areas which contain sulphur or sulphides such as iron sulphide, can generate acid through bacterial oxidation when exposed to moisture and oxygen - this acid leaching may then mobilize heavy metals that can be released into the environment;
- Loss of flora and fauna including direct losses through clearing and indirect effects due to the destruction of plant and animal habitats;
- Damage to heritage sites that attract tourists; and
- Destruction of adjacent habitats arising from the development of camps, towns and services stimulated by the mining project.

The following Policy Statements towards environmental sustainability and social support are proposed:

- Encourage alternative approaches which endeavor to address both mining and environment aims;
- Set and enforce mechanisms and guidelines for environment protection, mine clause, rehabilitation and resilience in mining;
- Enforce the health and safety standards;
- Control air and water pollution and contamination of surface or ground water by sediment, mobilization of salt, release of toxic elements from overburden, tailings or wastes, or spills of oil, chemicals or fuel as surface runoff or as underground seepage;
- Collaborate with stakeholders to integrate land-use planning with other economic activities including mining;
- Carry out the inventory of abandoned mines and the mines with historical mining legacies and design plan for rehabilitating abandoned mines and address the issues mining legacies.

The full-scale implementation and enforcement of the law and in conjunction with the strategies set out in the mining policy is required to mitigate and offset the environmental impacts of mining. Some of these impacts are discussed below.

3.3 Accounting for environmental externalities

According to Dubiński (2013) the negative impacts associated with mining include the deformations of soil surface in the form of subsidence, horizontal and discontinuous deformations, and mining induced seismicity activities. This disturbance of the soil strata contributes to changes in the quality of water and soils, and leads to the emission of gas, dust, noise and a reduction in water run-off, to mention but a few impacts. Additionally, mining induced changes also leads to changes in the natural topography resulting in land use restrictions for other purposes, changes in hydro-geological conditions with negative impacts on ground and surface water and changes in geotechnical conditions of the rocks (Nilsson & Randhem 2008). These negative impacts are intensified through open cast and surface mining, such as in Rwanda (Cao 2007). It degrades ecosystem functions because it removes vegetation, alters the hydrological cycle and soil conditions, disrupts fundamental ecological relationships, and reduces biodiversity (Li et al. 2011).

REMA (2015) recoginised this deterioration in enviormental quality and condition in Rwanda and noted the negative environmental legacy of waste dumps, mine tailing dams, and land degradation and the consequences thereof on water and related aspects. This is since open cast mining on steep slopes allows the waste rocks to flow downhill into surface water (lakes, streams, rivers, etc.). REMA thus noted that this legacy has a negative impact on the mining sector's reputation in Rwanda.

Further to REMA's observations there is evidence of an increase in widespread arable soil toxicity (Reetsch 2008; Flügge et al. 2009). It has also been estimated by Barreto et al. (2018) that, based on 2015 production figures, an estimated 110,000 tonnes of tailings were discharged into the environment. Mine tailings also contaminate surface and groundwater, making it difficult for local communities to access clean and drinking water (REMA 2011). The Audit Report of Environmental Management of Mining Activities in Rwanda (Office of the Auditor General of State Finances 2015) has therefore highlighted the following challenges with respect to mining activities:

- lack of management of topsoil from mining operations,
- lack of erosion control plan of mine sites,
- deforestation,
- mining undertaken in rivers and wetlands,
- lack of adequate facilities to capture wastewater from washing minerals and tailings, and
- lack of dust control to protect workers and surrounding community.

At the stage of rehabilitation and closure of mine sites, the Office of the Auditor General of State Finances (2015) highlighted a list of emerging issues also pertaining the mining sector, namely:

- lack of implementation of the Environmental Impact Assessment (EIA) and Environmental Management Plans (EMP),
- lack of timely rehabilitation of abandoned mine sites,
- lack of mine closure plans,
- some mine sites, the mining operations are only for subsurface mineralized portions, leaving mineral deposits behind, thus complicates and delays mine closure, or it provides the opportunity for re-opening of old mine in the future. Mine closure and rehabilitation are thus not a priority for some mining companies.

Accounting for environmental externalities: A list of possible actions

It is recommended, see also Chapter 4, that Rwanda undertakes a study to quantify the full extent of the environmental impact of mining, inclusive of the monetary valuation of these impacts. Such an assessment will have to consider, among others:

- The impact of mining on the rest of the country through increased soil erosion; see also Sections 3.4 and 3.5
  This assessment can, for example, consider the market value of topsoil in Rwanda, a proxy for its productive capability, is between US$34/tonne (RwF30,000) and US$57/tonne (RwF50,000). The loss of each tonne of topsoil thus contributes to a societal loss of this magnitude.
- The impact of mining of the productive capability of people either through a reduction in health, or through loss in life; see also Section 3.5.
  This assessment can, for example, make use of the human capital approach to value the impact of mining on the loss of life, or then the reduction in income as a result of mining. If it is assumed that the income of a person detrimentally affected by mining earned an income equivalent to the GDP/capita of US$787 per year, the net present value of the loss in income over 20 years, using a discount rate of 10%, equates to about US$7,000 per person.
- The opportunity cost of mining on the loss of agricultural revenue; see also Section 3.5.
  Pending the agricultural commodity produced in the area, the method in which it is produced and the yield thereof it is possible to estimate the loss in agricultural income due to mining.
- The impact of mining on the cost of and loss in hydro-power generation capability; see also Section 3.6.
  This could consider the additional cost in hydro-power generation due to increased turbine erosion and the need to consider an expansion of the hydro-power capability due to the loss of water storage capacity in the reservoir.
- The impact of mining on the cost of water treatment; see also Section 3.6.
  This could consider the additional cost in water treatment cost, current estimated to be about US$0.5/$m^3$, due to the increased sedimentation in the rivers.
- The opportunity cost of mining on the reduction in carbon sequestration capability of Rwanda.
  Pending the historic land-use, and the carbon sequestration capability thereof, should be considered relative to the carbon emissions generated by the mining sector.

Given this range of possible environmental impacts, a brief review of some of them will be provided below.

3.4 Mining and land use changes

Rwanda is no exception to the detrimental impacts of mining. Some of the impacts of mining to land surfaces are in Rwanda are:

- the destruction of natural ecosystems through the removal of soils and vegetation (Byizigiro et al. 2016);
- competing with agricultural land uses and often results in significant and irreversible impacts on environment (Haidula et al. 2011) and it leads to abandonment of cultivation practices and at the expense of small-scale farming;
- illegal mining inside the natural forests (Mukura, Gishwati, and Nyungwe), results in land use conflicts and expropriation of the nearby residents; and

- mining practices also leave behind waste dumps and degraded land and thus human-made landforms emerge as the discernible consequence of excavation in the course of mining activities. They are associated with artificially depressions such as pits and trenches. In places where intensive mining activity has occurred for many years, the landscape is potholed and covered in waste. The development of gullies following the excavation sometimes collapse and create sinkholes (Byizigiro *et al.* 2015).

If not permanent, the impacts of mining can last for many years. This necessitates the management of mining sites in an exemplary manner, during and after mining – and hence the newly introduced mining laws (see Section 3.2). The change of existing land use or securing access to land for new mining activities can be controversial for communities who may be affected (AGA 2009). For instance, open cast mining encroaches on arable lands which are zoned for farming. Many trees and forests are cut down making the place more susceptible for soil erosion thereby reducing the soil fertility. Minerals extraction leads to sub-optimal and much reduced farming activities and agricultural production due to land clearance, soil erosion and landscape degradation. Mine sites in Rwanda are mostly located close to farms with some agricultural activities taking place directly on mine waste deposits (Haidula et al. 2011). These conflicts between mining and agriculture require some households to be relocated and land users to be expropriated where minerals are to be mined.

Upper-Nyabarongo case study
According to ICMM (2015) the Upper-Nyabarongo catchment, e.g. the Gatumba area (Figure 15) soil erosion is common, also tailing dams, open pits and mineral washing in rivers/streams pollutes rivers and provide an image of lack of proper environmental protection measures. Sites that have been mined may still hold value for small-scale operators. The lack of proper rehabilitation of mine sites exacerbate the problem of topsoil losses because heavy rains continue to wash away the topsoil on unprotected mining sites (Bucagu et al. 2008). A large amount of waste is generated in form of soil and rock debris during mining, tailings from mineral processing plants and wastewater from mineral washing operations. Some of this waste is washed into the rivers, compounding the soil erosion on steep and highly cultivated slopes (Biryabarema et al. 2008). Lehmann et al. (2017) analysed the effects of mining activities on land use and land cover changes in Gatumba mining area revealed drastic land cover changes associated with the highest mining activities in 1974 (2017). From 1958 to 1974, woodland decreased by 54% and cropland increased rapidly. From 1974 to 2009 the process reversed, with woodland increasing while cropland decreased by 51%.

Figure 14: Landscape degradation in Gatumba mining area
Source: Photo: Gabineza (2016)

3.5 Mining impacts on soil and landscape degradation

Another important environmental concern relates to land degradation associated with operating and abandoned mine sites and the multiple trenches found across the hillsides. This can impact on residents by reducing land available for farming, while the open and un-fenced shafts and pits scattered across the area pose a risk to livestock and humans (Barreto et al. 2018). The most visible erosive features include rills, gullies, slides, topples, slumps and sinkholes. Depositional features include debris flows and tailing fans at the outlets of mine pits and interconnected channels that develop in downstream sedimentation (Byizigiro et al. 2015; Imanirareba & Naramabuye 2018). The extent of landscape degradation depends on the magnitude of human activity including the mining operations. If the disturbed landscape is not properly reclaimed, the removed topsoil, which would be necessary for subsequent reclamation measures, is not preserved. This reclamation of the land use is seriously hampered by the mining techniques used, which include excavation (cutting, trenching, pitting, striping, and sometimes shallow tunnelling), construction resulting in features like tailings dam, mine waste piles, rock dump and terraces, and diversion of stream flow.

Given the increasing demand for arable land by an ever-increasing population, adequate mitigation strategies using environmentally friendly reclamation techniques are becoming increasingly important (Byizigiro et al. 2015). Figure 15 illustrated mining induced degradation and soil movement in the

Nyamasheke District, which is the at the head of the Upper-Nyabarongo catchment impacting the entire catchment. The mine sites that are most exposed to landslide hazards were in Southern and Western Provinces (Figure 16). This is because of mountainous areas characterized by steep slopes, and landslides are induced by the mining activities resulting in environmental degradation, loss of lives and farmlands (Nsengiyumva et al. 2018; Bizimana & Sönmez 2015; Byizigiro et al. 2015). Unfortunately, this is not just a theoretical possibility as mining-related led to the tragic loss of life recently in the Rwamagana District. In total 14 miners were killed after the hill collapsed after heavy rains on 21 January 2019 (https://www.newtimes.co.rw/news/death-14-miners-was-preventable-labour-union).

Figure 15: Landscape degradation and mining induced soil movement in Nyamasheke District
Source: Photo: RMB (2018)

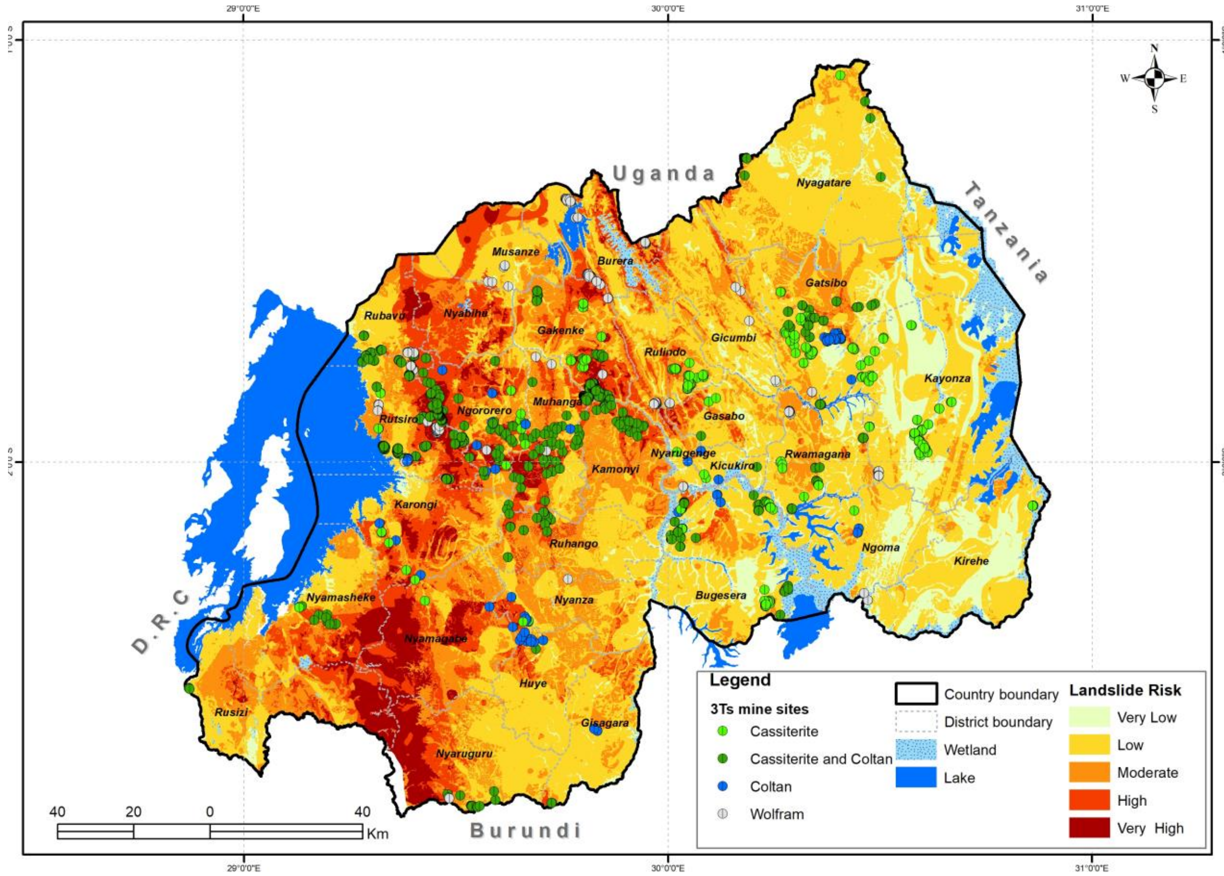

Figure 16: Location of mines and landslide prone areas
Source: RMB 2018 and MIDIMAR 2015

3.6 Impact of mining on rivers/streams and water quality

Small scale mining in Rwanda has local impacts on water quality with the potential for heavy metals (lead, cadmium, and zinc, copper) to accumulate in soils and enter the food chain, especially in floodplains used for agriculture and irrigation. For instance, open cast mining, such as at Bijyojyo, Mbobo and Gatumba (in the Upper-Nyabarongo District) is associated with environmental impact on water and river streams such as siltation due to the soil erosion and sedimentation, collapse of geomorphological structures induced by undercutting from clogging of stream channels, and subsidence if shallow galleries are developed with the removal of earth material from shallow underground. The debris flows and tailing fans develop at the outlets of mine pit, are associated with braided channels due to downstream sediments (Byizigiro 2016; Macháček & Dušková 2016).

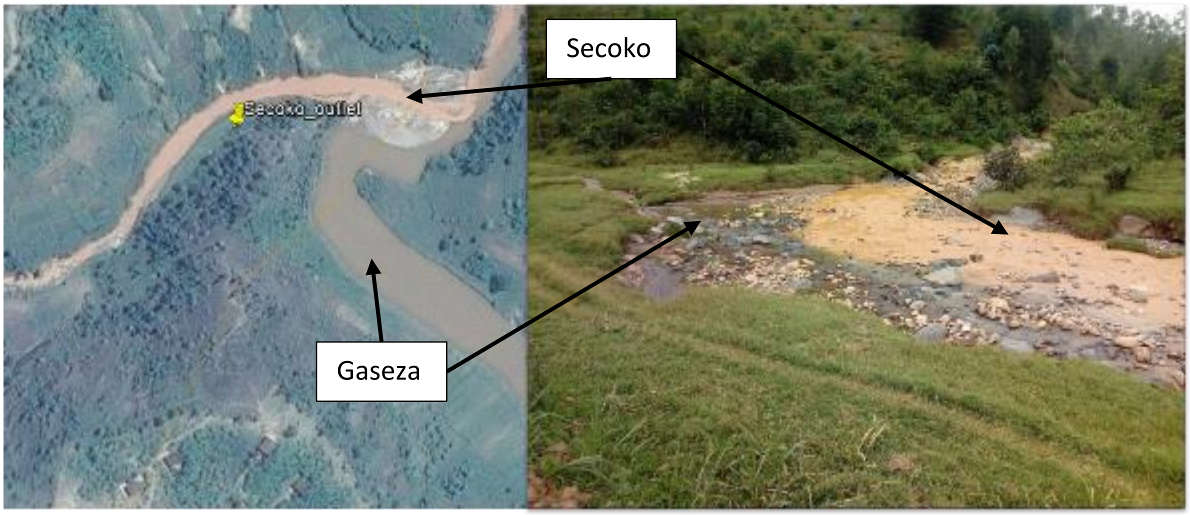

Figure 17: The confluence of the Gaseza and Secoko Rivers.
Source: Photo: Maximilien Usengumuremyi (2018)

Secoko case study
The impact of mining on the quality of water can clearly be seen in Figure 17. Figure 17 shows the confluence of the Gaseza and Secoko Rivers. The Gaseza River is clear during the dry months but becomes dark brown during the rainy season. Most of the sediments in the Gaseza are from riverbank erosion due the increase in peak flows which results from the changes in the hydrologic behaviour of the Gaseza River. The sediment in the Secoko River, however, is due to mining activities upstream. The effect that this sedimentation has on the entire system can clearly be seen in Figure 18. The sediment deposit at the top-end of the Upper-Nyabarongo hydro-power dam, restricting the reservoir's capacity and thus is increasingly reducing the hydro-power generation capability.

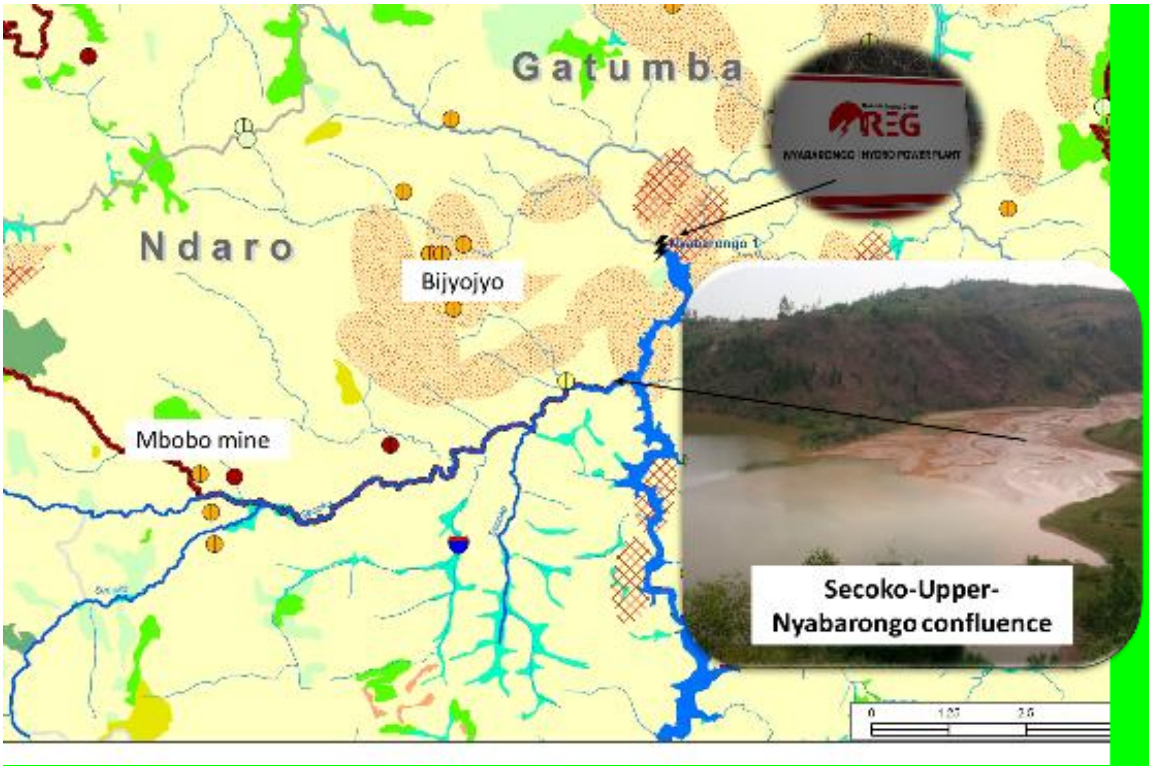

Figure 18: The Secoko outlet in the Upper-Nyabarongo River above the Upper-Nyabarongo hydro-power station

3.7 Summary

Based on the above issues there is an urgent need to address the environmental management practices and to enforce the environmental legislation actively. This is since the environmental impacts of mining pose multiple risks to human health, livelihoods, and economic development, with attention to mine waste and water management through introduction of basic systems within the workforce in order to ensure responsible practices proliferate across sites (Barreto et al. 2018). See also both Chapter 4 and Appendix 4. Appendix 4 refers to the Land-use Trade-off tool (LUTOT) developed for Rwanda to assist decision-making with respect to land-use options. The restoration of mined land can largely be considered as ecosystem reconstruction in order to re-establish the capability of the land to capture and retain fundamental resources. During the phase of mineral exploration and exploitation, all mining companies should follow the national planning guideline related to mining activities in Rwanda strictly (MINIRENA 2017).

4 Conclusion and recommendations

Introduction

The Government of Rwanda has placed much emphasis on the role and contribution of the mining sector to assist in the economic development of the country (Rwanda 2017). The sector has thus been steadily privatised and transformed over the past two decades from a publicly run one into an exclusively privately-run industry. The aim is to accelerate mining's contribution to export from about US$346 million in 2018 to US$1.5 billion by 2024 (Rwanda 2017; BNR 2019). It is anticipated that this can be accomplished by, among others, doubling the exports from the 3T's from US$142 million in 2018 to about US$300 million and to advance the export earnings from other minerals. In this regard a list of planned new mining projects is provided the adjacent box.

Planned new mining includes among others:

- Mawarid Nyanza coltan Project: with production projection of 300t of coltan per year equivalent to around US$50 million;
- NMC Gatumba cassiterite project;
- Pella Ltd's Project to produce 25 T of cassiterite and coltan per month;
- Fair Construction Ltd's project to exploit cassiterite in the former government concession of Nemba;
- Ngali Mining Ltd's project for Amethyst exploitation in Ngororero district;
- Gold project of Ngali Mining ltd in Miyove area (5 blocks) of Gicumbi district to operationalize the former gold mineralized area which in past was artisanal mined by local people.
- Other prospective areas for gold have been identified in Karongi, Nyamasheke and Rusizi districts respectively.
- Below are the key licensed areas for gold exploration and exploitation:
  - (i) Nine blocks for gold exploration in Rusizi district owned by Ngali Mining Ltd
  - (ii) Two blocks for gold exploitation in Gicumbi district close to Miyove area, owned by U.N.M.H Ltd
  - (iii) One block for gold exploration in Rusizi district owned by Faraise Company Ltd
  - (iv) There are also other areas in Karongi and Nyamasheke districts where prospective works are being conducted.
  - (v) Additionally, there is a seven-year deal worth $400 million with Gasmeth Energy Ltd to exploit gas from the bed of Lake Kivu and to bottle the gas.

Source: RMB based on personal communication

The mineral resource flow accounts, Chapter 2, indicated that the resource rents are, however, negative. This implies that the sector is illiquid. This illiquidity hampers the ability of the mining sector to implement the necessary remedial and corrective actions mentioned.

Improving the liquidity in the mining sector

Only a marginal increase of in unit prices between 3,5% and 3,6% is required to turn the negative rents to zero. It has been shown that an increase of, for example, 9% or 12% of the average unit prices received can change the fortunes of the industry considerably as that has the potential of generating, for 2016, resource rents of about US$11 and US$17 million respectively. There is much scope for such price increases as the differentials between the unit prices of the minerals received and that of the international metal prices are vast. Mechanisms, especially structurally, must therefore be explored to seek ways to improve the liquidity of the sector domestically. This change is, however, required to enable the sector to advance on its projected growth path, yet doing so in a way that will ensure that the resource rents turn positive and that the necessary safety, health and environmental measures are put in place to ensure sustainability. To achieve these increases in domestic prices an in-depth sectoral analysis is required.

Mineral accounts and the SDG's

Based on the information contained in Chapters 2 and 3 and combined with the recommendations made herein, the mineral accounts and work associated to it can contribute towards assisting Rwanda in achieving some of the Sustainable Development (SDG) goals of the United Nations (UN). A selection of the goals and their relevant targets are listed in Table 12 below.

Table 12: List of SDG's and their associated targets to which the mineral accounts and associated work contributes

SDG Goal	Target
Goal 1 End poverty in all its forms everywhere	1.1 By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day
Goal 6 Ensure availability and sustainable management of water and sanitation for all	6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally 6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes.
Goal 8 Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	8.1 Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 per cent gross domestic product growth per annum in the least developed countries 8.2 Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labour-intensive sectors 8.3 Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services 8.8 Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment
Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	9.2 Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries 9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities 9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending.
Goal 12. Ensure sustainable consumption and production patterns	12.2 By 2030, achieve the sustainable management and efficient use of natural resources 12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to

	air, water and soil in order to minimize their adverse impacts on human health and the environment 12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle.
Goal 13. Take urgent action to combat climate change and its impacts	13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries
Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements 15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally 15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development 15.8 By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species 15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts

Recommendations

Additional to the need for an in-depth sectoral analysis a range of recommendations is proposed. These recommendations are based on the mineral accounts, Chapter 2, but also several workshops held during 2018 and 2019 with the technical working group comprising members of RMB and NISR. The focus of these workshops was to ascertain what is needed to improve the efficacy of the mining sector of the sector to achieve its growth objectives and to contribute to the Rwandan economy. These can be found in Table 13 under four headings for varying timeframes, namely the short (0-24 months), medium (2 to 5 years), and long term (5years or more). The four headings are:

1. Mining structure;
2. Promote investment in mining;
3. Environmental management and health and safety; and
4. Data management.

Based on the above it can be concluded that the mineral accounts have highlighted some serious structural concerns within the Rwandan mining sector, but they also point to some options for remedial interventions.

Table 13: Policy recommendation to assist towards a sustainable mining sector in Rwanda

Mining structure		
Short term		
Recommendations	**Responsible agent**	**Description**
Improve knowledge on the available minerals	RMB & RDB	Provide information and incentives and finance mechanisms in support of mining in high-value and strategic mineral exploration by both the private and public sector.
Improve the process of issuing mining permits	RMB	Develop strict criteria with respect to the issuing of mining permits according to international best practises in order to improve the sector efficacy. Develop mineral exploration, operation and closure reporting standards and guidelines. Implement a protocol of ongoing and effective monitoring of mining activities to ensure adherence to the standards set in the mining law.
Improve the effective monitoring of mining activities and law enforcement	RMB & REMA & RDB	Develop guidelines for mineral exploration in relation to environmental impacts and monitor the implementation thereof. Ensure that each mining operation has an environmental management plan (EMP). Enforce the implementation of the EMP to be able to ensure compliance with the mining law and to adhere to best international practises with respect to safety, health and the environment.
Implement land-use masterplan in relation to mining activities	RLMUA	Develop the guidelines with respect to mining, such as the treatment of mining tailings, land management, and land use to implement the revised Land Use Master Plan. Monitor the implementation of the Land Use Master Plan in order to contribute to sustainable and long-term productive land use.

Medium term		
Recommendations	**Responsible agent**	**Description**
Pursue mineral diversification	RMB & RDB	Conduct advanced mineral exploration to diversify the mining sector to promote the investment in high-value minerals and metals.
Pursue value addition and beneficiation	RMB & RDB & UR	Conduct feasibility studies for processing plants (refineries and smelters) with a view to improving mineral value addition and increase revenues from exports. Promote the establishment of local research facilities and laboratories for testing and analysing mineral extracts with internationally recognised certification credentials.
Transformation of the small-scale mining	RMB	Develop a strategy to convert illegal mining practices to formal, sustainable and profitable businesses or co-operatives. This is to assist small and illegal mining operations to graduate from loss-making and informal operations to best practise. Monitor and enforce the legal regime so that mining operators comply with best mining practices and to increase professionalism and productivity in the sector.
Incentivise the modernisation of the mining sector	RMB & MINECOFIN & FONERWA	Develop a strategy for the modernisation of the mining sector in the medium to long-term. Issue permits to mining operators that demonstrates the use of international best practices with respect to technology and mine management. Establish financing mechanisms to facilitate the modernisation of the sector that might include access to funding, such as green bonds through FONERWA, with respect sustainable mining.
	MINECOFIN	Provide Financing mechanisms towards exploration surveys.
	RDB	Incentivise the sector to attract more private investors.

Promote investment in mining		
Short, medium and long term		
Recommendations	**Responsible agent**	**Description**
Investment in mineral exploration and reserves estimation	RMB	Conduct studies of exploration of all mineral potential and avail geological maps to attract potential investors.
	RDB	Attract investors in mineral reserves exploration and reserves estimation that comply with international best practises through marketing the country's resources responsibly.
	MINECOFIN	Provide a revolving finance mechanism to promote investment in exploration of Rwanda's mineral potential.
	NISR	Publish data on Rwanda mineral stocks.
	UR	Encourage geological studies in Rwanda's mineral potential.
Investment on improving technology, efficiency and productivity	RMB	Attract investors who demonstrate the use of best international practises and technologies to the betterment and modernisation of the sector. Develop strategies to assist existing companies to adopt the use of best international practises and technologies to increase productivity.
	RDB	Attract investors that will invest in the best technologies to assist in the modernisation of the mining sector to increase productivity through international marketing.
	MINECOFIN	Develop innovative financing mechanisms and instruments in partnership with private financial institutions that will encourage the modernisation of the mining sector.
	UR	Encourage studies on the productivity of alternative technologies.
Investment in training and sensitization to promote professionalism	RMB	Enforce the implementation of article 24(3) of the mining law towards the enhanced capacity-building of the sector.
	UR	Develop curriculum and train mining operators to work professionally.
	MINECOFIN	Develop innovative financing mechanisms and instruments in partnership with private financial institutions that will encourage the training of mining operators to work professionally.

Investment in mineral diversification	RMB, RDB & MINECOFIN	Develop an institutional and regulatory environment that will enable and facilitate the availability of both private and public funds for high-value mining operations that complies with international best practises to the benefit of Rwanda.
Investment in local processing of minerals	RMB, RDB & MINECOFIN	Develop an institutional and regulatory environment that will enable and facilitate the availability of both private and public funds promote the local processing of minerals for greater value added and domestic capture of benefits for greater value added and local befits.
Invest in the long-term development of Rwanda using its mineral wealth	RMB & MINECOFIN	Use royalties in the best interest of Rwanda's economic development and the promotion and modernisation of its mining sector.

Environmental management, health and safety		
Short term		
Recommendations	**Responsible agent**	**Description**
Enforcement of environmental and social assessment and monitoring (EIA, SIA, EMP)	RMB, REMA, RAPEP	Establish an environmental and social assessment in mining training and accreditation program for environmental practitioners to upskill monitoring agents. Enforce the recommendations as contained in the EIA, SIA and EMP.
	RMB, REMA & RDB	Improve transparency of environmental and social commitments and increase mine inspections to ensure mine accountability and compliance. Ensure the enforcement of ongoing protection of water ways, regulation and enforcement of wastewater in mine sites.
Enforce occupational health and safety (OHS)	RMB & RMA	Establish OHS best practice guidelines/program at all mines and quarries sites. Establish OHS incident reporting, establish formal grievance procedures for mine and quarries sites and ensure accountability and responsibility of mining companies. Standardise basic employment conditions and enforce such across mining sector. Ensure that mining companies take out insurance to compensate miners and their families in the case of injury or death.
Enforce the rehabilitation and restoration of mining sites	RMB, REMA & RWFA	Enforce mining closure, including the use of mine tailings, and the restoration of the mining site to be conducive for further development according to the mining law.
	RMB, REMA & RWFA	Ensure rehabilitation and closure of mines according to the EIA and EMP and Articles 40, 41 and 42 of the mining law.

Enforce orderly decommissioning and reutilisation of mining sites after operation	RMB & REMA	Ensure that closure plans prepared by mining companies are of a high standard and are updated regularly. Ensure that the environment bonds are enough to finance mine closure and mine rehabilitation.
	RMB & REMA	Develop a mine rehabilitation program for orphaned and abandoned mines for them to be re-utilised for other productive economic activities. Use unutilised environmental bonds for restoration of abandoned mining sites.
Internalisation of the cost of externalities	RMB & REMA & MINECOFIN	Conduct a detailed assessment with respect to the value of environmental externalities associated with mining operations.
Medium & long term		
Recommendations	**Responsible agent**	**Description**
Enforce the rehabilitation and restoration of mining sites	RMB, RWFA & FONERWA	Implement innovative finance mechanisms/instruments, such as PES, to upscale restoration country-wide in the mining sector.
	MINECOFIN	Improve integrated economic and environmental modelling that includes mining externalities and the cost of mine rehabilitation.
	RMB & RLMUA	Operationalise the Land-use Trade-off tool (LUTOT) developed for mining sector to assist technical decision making with respect to land-use options in mining concessions.
Enforce orderly decommissioning and reutilisation of mining sites after operation	RMB, MINECOFIN, REMA	Develop financial insurance schemes to reduce the risks associated with inadequate mine closure and rehabilitation plans and mechanisms.
		Develop, monitor the implementation of long-term mine closure plans to ensure risks such as subsidence, mine waste and mine fines storage stability, acid drainage is adequately addressed.

Data management		
Short term		
Recommendations	**Responsible agent**	**Description**
Spatial data management	RMB	Consolidate database and improve accessibility thereof with respect to the location of mining sites. Update and complete existing geological and mineral maps.
	REMA	Consolidate database and improve accessibility thereof with respect to the impact of erosion and the environmental impact of mining.
	RLMUA	Improve and standardise the collecting and reporting of spatial data related to mining and improve the accessibility of the data.
Physical data management	RMB	Harmonise the gathering of geological and mineral deposit data.
	RMB	Develop high-quality data capturing, processing and archiving system with seamless integration between mine sites in collaboration with ITRI.
	REMA & MINECOFIN	Estimate the generation of sediments and other environmental impacts associated with mining. Estimate the value of the externalities associated with mining.
Financial and economic data management	RMB & NISR	RMB and NISR to collaborate with respect to IBES in terms of: - questionnaire design - mining companies (operators and traders) to be surveyed - improvement and standardisation of the categorisation of the companies surveyed in terms of level-6 ISIC code - frequent publication of IBES using a consistent and comparative framework and categorisation of companies.
	RMB	Develop and implement a research portfolio that includes the investigation of the use of economic turn-around policies successfully applied globally within the mining sector.
Data sharing	RMB	Improve the sharing of data in terms of technological advances to improve the extraction and beneficiation efficiency.

Medium and long term		
Recommendations	**Responsible agent**	**Description**
Spatial data management	RMB, REMA, RLMUA	Improve data storage and dissemination through an electronic online system using a centralised database. Construct GIS platform to provide modern digital geological and minerals maps, and mine production data and statistics. Install integrated mineral cadastre and GIS facilit for monitoring, management of mineral tenure, mining projects, mining operations, and traceability. Design long-term programme of geological surveys for the whole country especially in the strategic target areas to attract investment, promote mineral exploration and inform public policy in Rwanda.
Financial and economic data management	RMB & NISR	Improve data storage and dissemination through an electronic online system using a centralised database.
	MINECOFIN	Improve integrated economic and environmental modelling that includes mining externalities and the cost of mine rehabilitation.
	NISR	Integrate financial and economic data from the Mineral Accounts with that from the National Accounts through the development of a satellite accounting system and the regular publication thereof.

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Appendix 1: Mining in Rwanda: a historic overview of its institutional development[2]

During the colonial era in the 19th century, Rwanda, Burundi and Tanzania formed German East Africa, but after World War I, Rwanda and Burundi were placed under Belgian administration. The first geological observations for Rwanda were made during the visit of the German Duke Mecklenburg during 1909 in the context of analysing the chain of volcanoes but also from another study conducted by a geologist called Meyer at around the same time.

Between 1920 and 1930, some Belgians rushed to Rwanda hoping to find the same mineral wealth as in Katanga (Congo) where a mining union known as U.M.H.K (Union Minière du Haut Katanga) had prospered for 15 years. The Bank of Brussels accepted to finance a systematic geological study to determine mineral potential in both Rwanda and Burundi.

Between 1922 and 1923, the first geological mission conducted by Saléé, a lecturer at Louvain Catholic University, and a geologist called Delhaye, provided necessary data for elaboration of the first geological map of Rwanda and Burundi at a scale of 1:200,000. The map was published in 1926. Between 1925 and 1927 Salée and an engineer called Newpot established geological data on the eastern part of Rwanda but mining activities only started in 1930 with two main companies: Rwanda – Urundi Tin Mines Company (MINETAIN: Société des Mines d'Etain du Rwanda-Urundi) and Muhinga and Kigali Mining Company (SOMUKI: Société Minière de Muhinga et de Kigali) in 1934. After this point, a few other mining companies were established including GEORWANDA and COREM in 1945 and 1948 respectively.

After independence, the government of Rwanda decided to create a public mining company by grouping together all existing mining companies in order to try to strengthen the industry. On February the 9th 1973 the status of SOMIRWA (Société Minière du Rwanda) was adopted on one side by the government of Rwanda represented by the Minister of Finances and on the other side two mining companies (SOMUKI and MINETAIN) – the government held minority shares (49%).

Immediately after its creation, SOMIRWA had to face many problems inherited from the old mining companies from which it had taken over most of the concessions and facilities. The problems related to outdated production equipment, the poor state of the mining infrastructure, the delay of preparatory work and a lack of spare parts. To address these problems, a five-year recovery plan (1977-1981) was introduced with expenditures in the order of one billion Rwandan francs including the construction of a tin smelter. The recovery plan established targets to increase the production of cassiterite and wolframite from 2,200t and 825t in 1976 to 2,500t and 1,500t per year in 1981. However, the results of this recovery plan were disappointing.

Other development plans were initiated but the donors were not convinced by the study which was presented and refused to grant the necessary funding. They demanded that the government of Rwanda endorse the loan, but the government refused because it had begun to distrust the management of the company. Ultimately SOMIRWA could not recover from its difficulties and on 23 July 1985 fell into bankruptcy due primarily to low tin prices, heavy investment in the smelter which did not bring enough returns and poor management.

[2] Based on the RMB (2018a).

After this collapse, from September 1986 to December 1988, the government provided a caretaking of concessions and their dependent property at the cost of 100 million Rwandan francs per year. In 1988 COPIMAR (Coopérative de Promotion de l'Industrie Minière Artisanale au Rwanda) was founded on the initiative of the Government of Rwanda to reinvigorate the sector of artisanal mining that was practically extinct.

In 1989 REDEMI, a public company was established to continue the work of mining and exploration till another round of privatization was possible. In January 1989, the Régie d'Exploitation et de Développement des Mines (REDEMI) launched its mining activities on all concessions of SOMIRWA which had a total area of 104,000 ha with a capital of 97,225,000 francs granted by the Government of Rwanda.

Given this long history, there was significant potential for the mining industry to have a strong positive impact on the Rwandan economy. From 1930 to 1968, mining production increased from 20% to 42.5% of all foreign exchange earnings of the country. However, between 1969 and 1973, the share of mineral revenues decreased from 42.5% to 21.6% due to a lack of investment after independence. While the creation of SOMIRWA aimed to turnaround the industry and increase the export earnings of minerals, but as we have seen this did not happen and from 1980 until 1984 production fell leading to revenues not exceeding 10%. After 1994, there was a gradual recovery of revenues due to increased government support and focus, with exports growing gradually to reach 45.7% of total exports in 2001. In 2007 when it was dissolved and its operations were made available to the private sector, upon application for a known concession by any private operator.

In 2007 OGMR (Office de la Géologie et des Mines du Rwanda) was created to take over the activities of REDEMI, after the decision to privatize the industry in 2006. The new institution was charged with service provision and regulation of the industry. In January 2011 OGMR changed name and was called GMD (Geology and Mines Department, under the former Ministry of Natural Resources - MINIRENA) but the vision and the mission still stayed the same. Subsequently the Government has launched a series of reforms ranging from fiscal incentives, privatization of operations, liberalization of the sector, and most recently the establishment of the Rwanda Mines, Petroleum and Gas Board (RMB) (February 2017) as a quasi-autonomous entity to manage the sector. Law Nº07/2017 of 03/02/2017 establishes Rwanda Mines, Petroleum and Gas Board (RMB) and determines its mission, organisation and functioning. The law specifies that RMB falls within the category of non-commercial public institutions. A Rwandan non-commercial public institution is a government-owned institution, run under annual government budget extended in order to provide services assigned to it for purposes of general interest and governed by the general legal provisions governing the functioning and management of public services[3]. RMB's main missions include the following: (i) to implement national policies, laws and strategies related to mines, petroleum and gas; (ii) to advise the Government on issues related to mines, petroleum and gas; (iii) to monitor and coordinate the implementation of strategies related to mines, petroleum and gas; (iv) to conduct research in geology, mining, petroleum and gas and disseminate research findings; (v) to carry out mineral, petroleum and gas resources exploration operations in the country; (6) to provide advice on the establishment of standards and regulations in mining, petroleum and gas; (7) to supervise and monitor public or private entities conducting mining, trade and value addition of minerals operations;

[3] More on this can be found under the "The organic law No.001/2016/OL of 20/04/2016 establishing general provisions governing public institutions".

(8) to assist the Government in valuing mining and quarry concessions. RMB works under the management of a board of directors and an executive organ. The executive organ of RMB is composed of the Chief Executive Officer (CEO) appointed by a presidential order and other staff members recruited in accordance with relevant laws.

Appendix 2: List of laws, Ministerial orders and policies related to mining in Rwanda

i. Law N° 58/2018 Of 13/08/2018 on Mining and Quarry Operations
ii. Law N° 13/2014 of 20/05/2014 on Mining and Quarry Exploitation
iii. Ministerial Order N°003/MINIFORM/2010 of 14/09/2010 on Requirements for Granting the License for Purchasing and Selling Mineral Substances in Rwanda
iv. Ministerial order n°001/MINIRENA/2015 of 24/04/2015 determining modalities and requirements for the financial guarantee of environmental protection and its use in mining operations.
v. Law N° 04/2005 of 08/04/2005 Organic Law Determining the Modalities of Protection, Conservation and Promotion of Environment in Rwanda
vi. Law N°. 13/2009 of 27/05/2009 speak to Rwanda's National Child Labour Policy
vii. Law N° 06/2015 of 28/03/2015 Relating to Investment Promotion and Facilitation
viii. Law N° 43/2013 of 16/06/2013 Determining the Use and Management of Land in Rwanda
ix. Law Nº47bis/2013 OF 28/06/2013 Determining the Management and Utilization of Forests in Rwanda
x. Law N° 55/2013 of 02/08/2013 on Mineral Tax
xi. Law N°62/2008 of 10/09/2008 Putting in Place the Use, Conservation, Protection and Management of Water Resources Regulations
xii. Law N° 63/2013 of 27/08/2013 Determining the Mission, Organization and Functioning of Rwanda Environment Management Authority (REMA)
xiii. Law N° 70/2013 of 02/09/2013 Governing Biodiversity in Rwanda
xiv. Ministerial Order N°001/MINIFORM/2010 of 10/03/2010 Fighting Smuggling in Mineral Trading
xv. Ministerial Order N°001/MINIRENA/2015 Regarding the Environmental Guarantee Fund
xvi. Ministerial Order N°002/MINIRENA/2015 of 24/04/2015 on Criteria Used in Categorisation of Mines and Determining Types of Mines
xvii. Ministerial Order N°003/MINIRENA/2015 of 24/04/2015 Determining Modalities for Application, Issuance, and Use of Mineral and Quarry Licenses
xviii. Ministerial Instruction N°010/MINIRENA/2016 of 11/01/2016 Determining Types, Size Limits, and Modalities for Exporting Mineral Ore Samples
xix. Republic of Rwanda (2018). Law on mining and quarry operations, Official Gazette nº33 of 13/08/2018.
xx. Law nº07/2017 of 03/02/2017 establishing Rwanda mines, petroleum and gas board and determining its mission, organisation and functioning
xxi. Ministerial instructions no 010/minirena/2016 of 11/01/2016 determining types, size limits and modalities for exporting mineral ore samples
xxii. Ministerial order n°001/minirena/2015 of 24/04/2015 determining modalities and requirements for the financial guarantee of environmental protection and its use in mining operations

Appendix 3: Mining in Rwanda: A biophysical perspective

Geology

Rwanda's landscape is hosted in the Kibaran Belt which is the main geological structure of the Great Lakes Region (Dewaele et al. 2011). It is composed of metamorphosed sediments, mainly schists and quartzite intruded by two main phases of granites covering the largest part of Rwanda (Dewaele et al. 2010). This geological structure is dominated by tin and tantalum mineralization-bearing pegmatites. Primary tin and tungsten mineralization is related to hydrothermal quartz veins, and gold mineralization is related to hydrothermal quartz vein (Dewaele et al. 2010; Hulsbosch et al. 2013). The map in Figure 19 illustrates the geology of Rwanda. As per the way forward in Chapter 4, Rwanda must invest in a high-quality cadastre and GIS platform to inform better decision-making in the mining sector.

The geological map of Rwanda exists at 1:250,000 scale and twelve (12) (hard copy) sheets at a regional level with a scale of 1:100,000 are available (Theunissen et al. 1991). This scale is however not useful for mineral explorations. As mentioned, a more detailed geological map focusing on mineral exploration and exploitation must be purposively established in order to show the patterns of minerals occurrence (Muchez et al. 2014). Further geological information on mining areas is available (most of which in hard copy format) in the archives of Rwanda Mines, Petroleum and Gas Board (Kigali-Rwanda) and at the Royal Museum for Central Africa (RMCA), Tervuren (Brussels-Belgium). A process is ongoing between the RMB and the RMCA to transfer available digital information to the RMB.

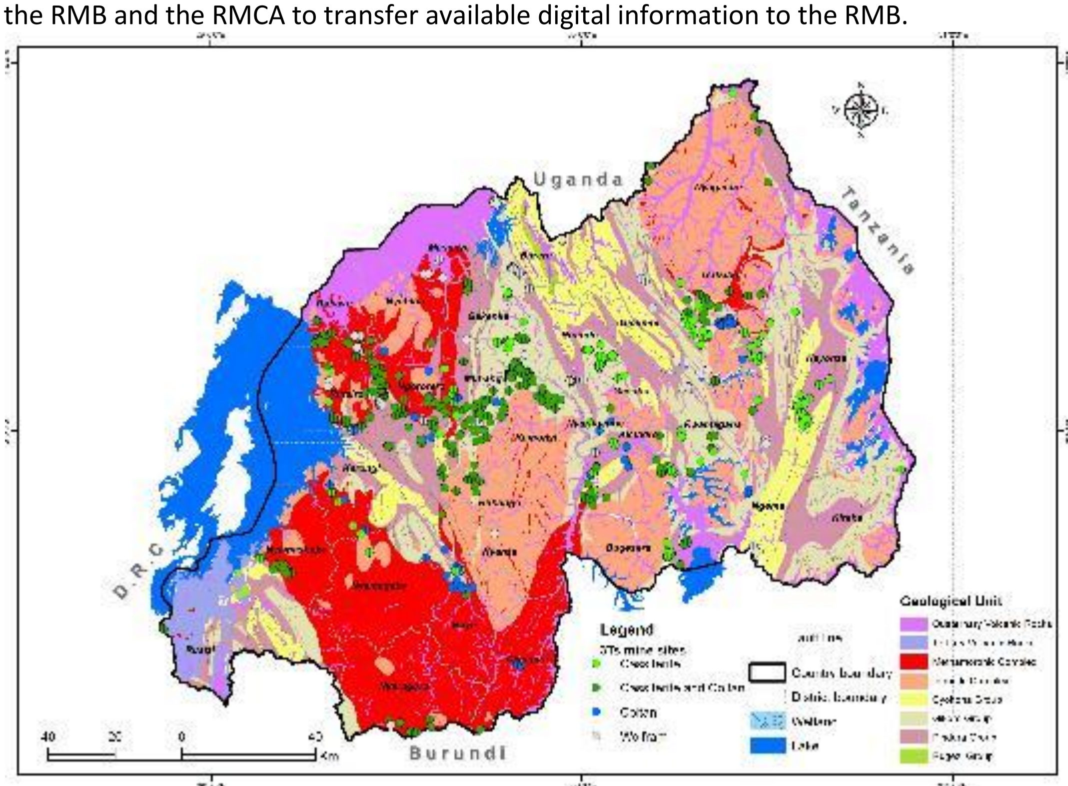


Figure 19: Geological map of Rwanda
Source: RMB (2018c) based on Theunissen et al. (1991).

Metallogeny of Rwanda

Late phases of granite intrusion in the form of pegmatite bodies and hydrothermal quartz veins which, in contact with the host rocks, induced various types of alteration such as muscovitisation, kaolinization, sericitisation etc. are the major drivers of minerals occurrence of Rwanda (Varlamoff 1972). Mineral resources are structure-controlled and are linked to pegmatite and/or hydrothermal quartz veins resulting from syn- to post tectonic pegmatite intrusion (Misener et al. 2011). Key minerals include cassiterite (SnO_2), columbite-tantalite ((Fe, Mn) (Ta)2O6), wolframite (Fe, Mn) WO_4 and native gold (Au) (Heizmann & Liebetrau 2017). These minerals tend to concentrate near the contact hydrothermal veins-host rocks (Varlamoff 1972; Heizmann & Liebetrau 2017). The current minerals map of Rwanda, shown in Figure 20, is dated as well and is also a scanned version of a hard copy.

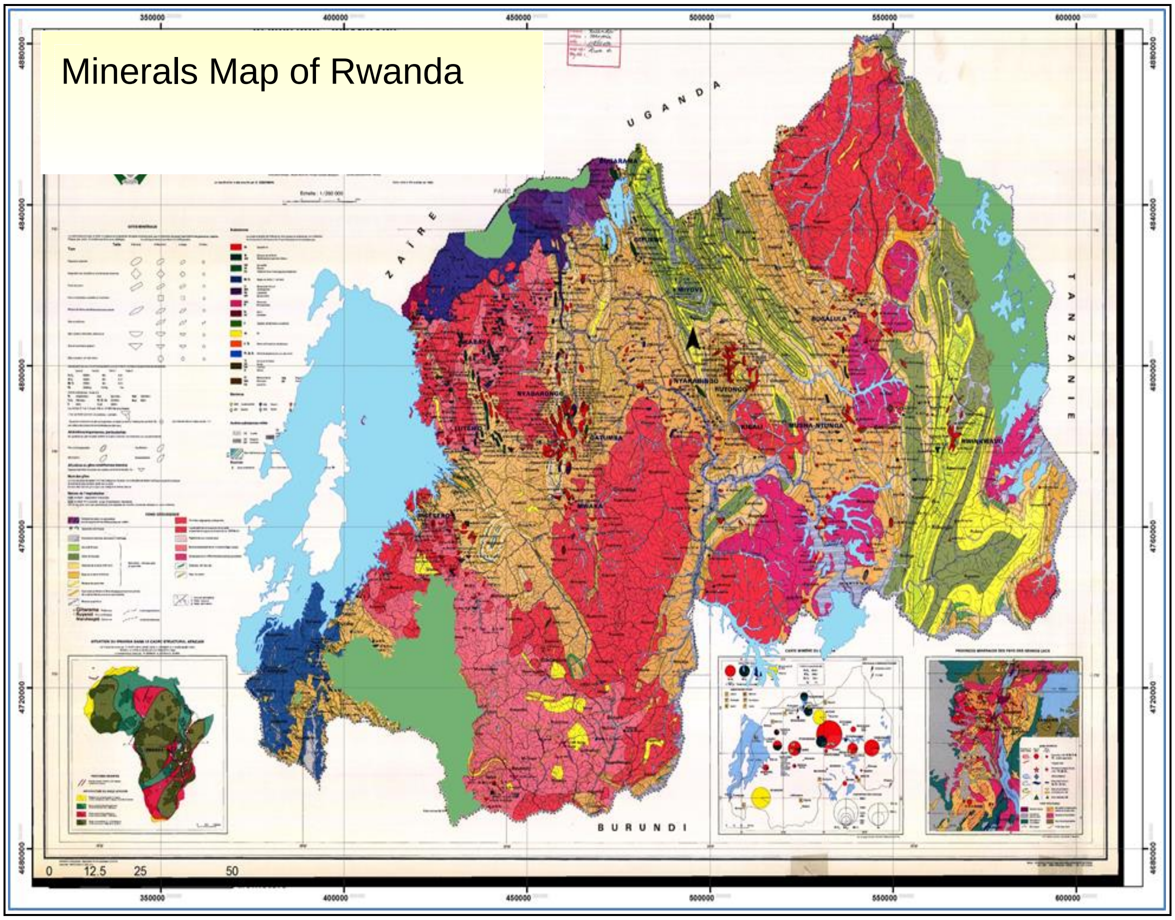


Figure 20: Minerals map of Rwanda: 1987
Source: BRGM (1987)

The mining products in Rwanda are mainly the so-called 3T's which are tin, tungsten and tantalum metal ores (respectively cassiterite, columbite-tantalite and wolframite minerals) (MINIRENA 2013). Wolframite which is often associated with cassiterite and is an iron manganese tungstate mineral from which tungsten (W) is derived. Columbite and tantalite is a solid solution with respectively Nb- and Ta-end members coexisting in the nature in the form of columbite-tantalite. Other key minerals being mined in Rwanda are gold, sapphires, amblygonite, spodumene, beryl and semi-precious stones such as tourmaline, topaz, corundum, chiastolite, amethyst, opal, agate and flint (REMA 2015; Yager 2016).

These minerals are mined in Rwanda for more than 80 years (Dusková & Machácek 2014). The mineral exploration started since 1920's. The deposits of cassiterite have been discovered for the first time in Rwinkwavu and Rutongo in 1930's. From that period, mineral exploration has been intensified in Bisesero and Gatumba and as well as in Musha-Ntunga, Mugesera and Bugesera between 1931 and 1941. Another discovery of cassiterite, columbite-tantalite and wolframite were made at Rutsiro in 1933. Between 1940 and 1950, wolframite was discovered in Gifurwe, Nyakabingo and Bugarama (IM International Consulting Group 2016). The post-independence discoveries include thorium and uranium at Karago in Nyabihu district and Nshiri in Nyaruguru district; monazite in Musebeya (Nyamagabe District); Gold in Nyungwe area (astride Nyamagabe, Rusizi and Nyamasheke Districts), wolframite in Rutsiro, Musanze, Burera, Gakenke, Rwamagana, and Rulindo Districts; and cassiterite and tantalite in Muhanga, Karongi, Ngoma, Nyagatare and Rusizi between 1968 and 1985. Between 1978 and 1979, more discoveries comprising gold were made in Miyove and Kinyami in Gicumbi District, few micro-diamonds were discovered during the UNDP project at Gatebe in Gicumbi District, and wolframite near Bugarama, Gifurwe in Burera District, and Nyakabingo in Rulindo District.

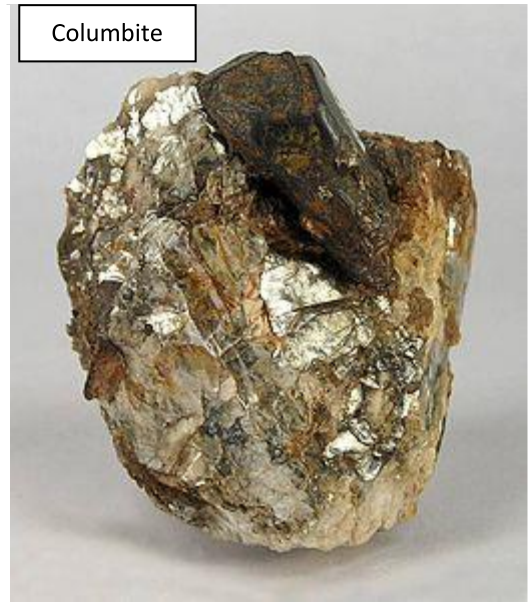
Rwanda is situated in a large belt hosting a significant metallogenic collection of numerous ore deposits including Nb, Ta, Sn, W, Au. The basic ore geology of this belt has been summarized in three main types: (i) Pegmatite hosted tin and tantalum mineralization, (ii) Hydrothermal tin and tungsten mineralization in quartz veins, and (iii) Hydrothermal gold quartz vein and breccia related mineralization (Pohl 1987; Pohl, Biryabarema, & Lehmann 2013). In Rwanda, most economically pegmatite can be classified as Li-Cs-Ta bearing, while intensely altered pegmatites tend to bear smaller grained barren rocks and target minerals (Varlamoff 1972). Tantalite, Tin, and Tungsten exploited in Rwanda have the features describe below.

Cassiterite is a tin oxide mineral whose chemical composition is SnO_2. Tin is commonly used in solders, tin plating, electrical conductors, and other applications in the electronics industry. Cassiterite has a yellow brownish to black colour and a light brown to light grey streak. The main sorting criterion that will be used within the test series is its high specific gravity of around 7 g/cm³. A secondary sorting criterion is the nonmagnetic property of cassiterite, which allows separation from other ferro- or paramagnetic dense minerals, notably tantalite.

Tantalite most known as Coltan is of a dark brown to black colour and a brownish-red to black streak ((Fe, Mn) $(Ta)_2O_6$). Two ore groups, columbite and tantalite, share similar features and are often grouped together into one mineral series and referred to as coltan (Ta). Tantalum is used in fabricating capacitors for electric products. The low paramagnetic properties of tantalite allow separating it from ferro- and non-magnetic minerals such as cassiterite (Okrusch & Matthes 2009, cited by Heizmann 2017). It is important to note that Coltan is an informal trade name for minerals of the columbite-tantalite series and additional Ta- and Nb-bearing minerals. Tantalite is usually the main Ta-bearing mineral. Columbite ((Fe, Mn) Nb_2O_6) is the main Nb bearing mineral. Other Ta-bearing minerals included in coltan in various proportions are microlite, wodginite and tapiolite (Heizmann 2017).

Coltan (Columbite-tantalite)

Columbite



Wolframite is an iron manganese tungstate mineral from which tungsten (W) is derived. Tungsten and its alloys are important electrical conductors. Wolframite is often associated with cassiterite. Wolframite ((Fe, Mn) WO_4) is an iron manganese tungstate mineral. It is a mixture of the minerals ferberite (Fe^{2+}-rich) and huebnerite (Mn^{2+}-rich). Wolframite is monoclinic and has a dark grey to brownish colour with a reddish-brown streak. Its fracture is uneven and rough.

Appendix 4: Land use trade-off analysis tool for Rwanda (LUTOT)

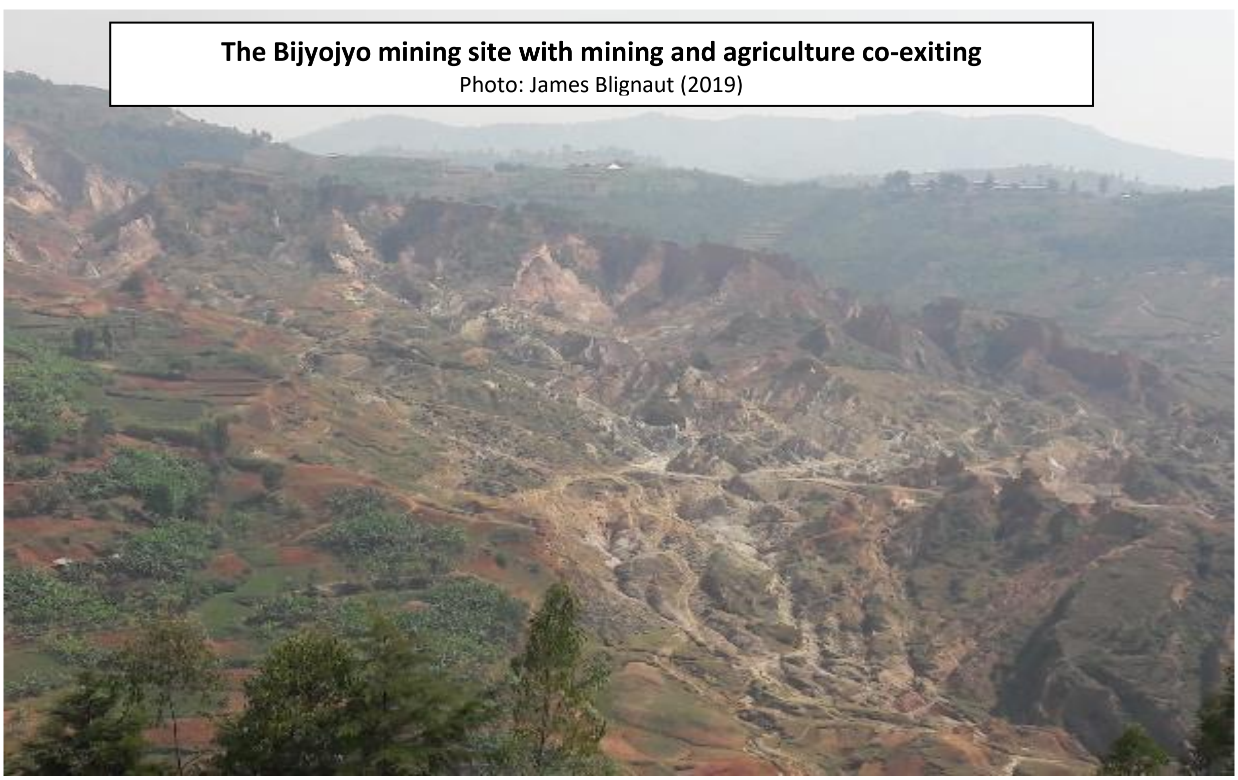
Introduction

Given the environmental impacts of mining in Rwanda, see Chapter 3, land resources must be managed with much greater care to promote sustainable and environmental sound socio-economic development. As a result of many land use options available on a single parcel of land, land use conflict is a regular occurrence. The sensitivity and seriousness of this conflict is nowhere greater than among mining and agriculture because of the wide-scale and radical impact mining has producing potentially significant streams of income in the short term, while agriculture is producing food over the longer term.

In the context of Rwanda where resources are scarce due to a growing demand, it is important to have a comprehensive understanding of the quantity and quality of available land resources, resources use options and to evaluate options to determine the most sustainable land use option for a given site. It is important to evaluate and compare different land use options for the above-mentioned purposes. In this regard, a Land Use Trade-off Tool (LUTOT) was developed to support decision making in land use options based on evidences (MINIRENA LUTOT 2018).

LUTOT makes provision for four possible land use scenarios with the option to contrast the economic impact of the various land use options. These scenarios are:

1. (S1) small scale agriculture practices without mining,
2. (S2) improved agriculture practices (professional farming) without mining,
3. (S3) artisanal mining and small-scale farming activities and
4. (S4) professional mining and agriculture.



The Bijyojyo mining site with mining and agriculture co-exiting
Photo: James Blignaut (2019)

Site description

The case study presented here refers to the Upper Nyabarongo catchment in the Ngororero district. The site (see Figure 21; see also Figure 18) is characterised by artisanal mining activities as well as subsistence agriculture and is very degraded. The total size of the land parcel under investigation is estimated to be 23,565 ha with an estimated population of about 3,169. The current land use is dominated by agriculture on intermediate slopes, and the dominant soil type is Acrisols (see MINIRENA LUTOT 2018). Given the fact that there are ongoing mining activities in the catchment means that only two scenarios are possible, namely: (1) a baseline scenario in which mining has already taken place, and (ii) a best-case scenario that refers to improvement in both mining and agriculture techniques and proper rehabilitation post mining. Improved agriculture includes the use of appropriate fertilizer and manure (Morris et al. 2007; Snijders et al. 2009). Professional mining implies using improved equipment such as drills, shovels, loading and processing machinery that would yield more cassiterite, coltan and wolfram (Fourie 2016).

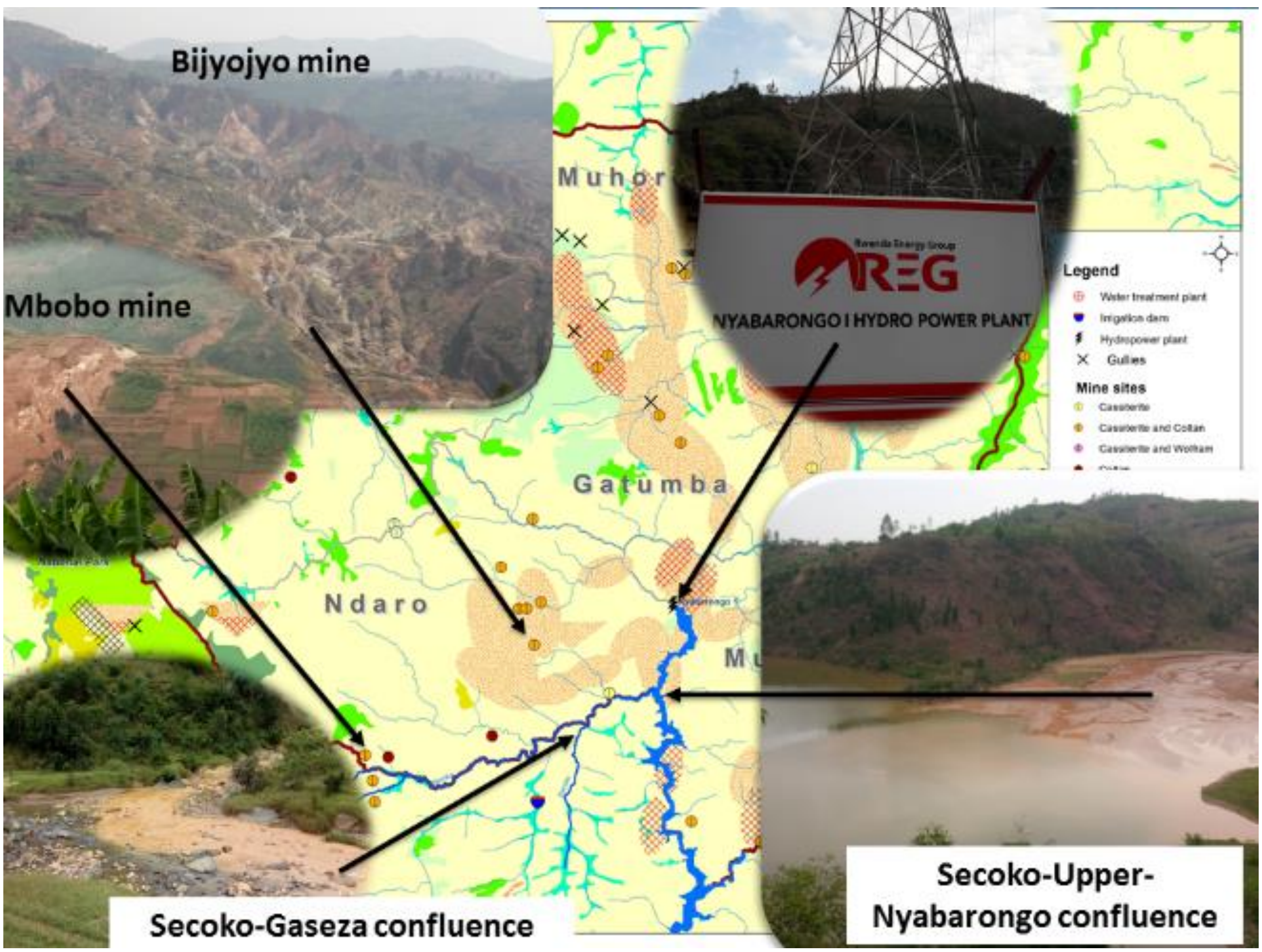


Figure 21: Location of the study area in the upper Nyabarongo catchment area

Results and discussion

The results as per the LUTOT is provided below (Figure 22). Scenario S3 reflects the current (baseline) scenario, with S4 the scenario with improved mining, restoration and quality agriculture. Figure 22 contrasts the net present value (NPV) of the two scenarios after a period of 30 years. Scenario S4 is indicated as having a much higher NPV (RwF 83 million) compared to that of S3 (RwF 56 million). It is a clear indication that if the Government of Rwanda wants to promote economic development as well as environmental protection, scenario S4 is by far the best option.

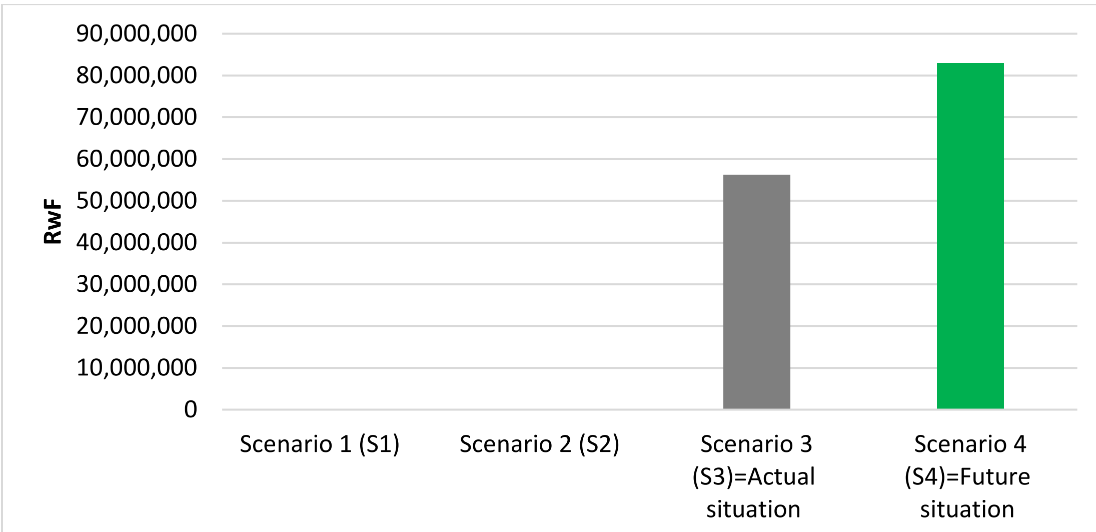


Figure 22: LUTOT results: Net Present Value

Source: MINIRENA LUTOT (2018).