Unpacking the Nexus between Climate Change and Extractive Industries in Sub-Saharan Africa

KONRAD ADENAUER STIFTUNG

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Preface

In a bid to align with the obligation of the 2015 Paris Agreement to limit global warming to below 2°C compared to pre-industrial levels, more and more countries are introducing strategies to reduce their national emission of greenhouse gases (GHGs) over the coming decades. In the wake of the 26th Conference of the Parties (COP26) that took place in Glasgow in November 2021, countries such as the United States, Germany and China had pledged to significantly reduce their carbon emissions in the coming decades and to become carbon neutral by 2050 and 2060 respectively.

A substantial element of the transition towards carbon neutrality is the phasing out of fossil fuels and its replacement with renewable energies and green technologies. However, the move towards a low-carbon future will require vast quantities of minerals and metals; for instance, at least 16 different minerals or metals are needed to produce solar panels. Wind turbines and energy storage technologies also require mineral and metal intensive inputs. It is predicted that metals demand between 2021 and 2050 will likely double for wind and solar technologies, and even more for battery storage technologies. The shift to a low-carbon future, therefore, presents global opportunities for Africa with its huge reserves in some of the key minerals such as platinum, manganese, cobalt, copper and bauxite. Access and availability of these minerals will increasingly determine the geopolitics of decarbonisation.

At the same time, the global volume of GHG emissions attributable to primary mineral and metal production is significant. Given the impact of GHGs on global warming, it becomes evident that mining companies play a pivotal role in addressing climate change by reducing their carbon footprint and consequently contributing towards a low-carbon transition as outlined in the Paris Agreement.

Together with our partner, the Southern African Resource Watch, Konrad-Adenauer-Stiftung want to shape the discussion on potential scenarios for a low-carbon future in line with Goal 13 of the Sustainable Development Goals (SDGs) on Climate Action. Given the importance of minerals and metals, we are focussing on the role of the extractive industries in the transition towards decarbonisation and sustainable and inclusive growth for Sub-Saharan Africa. This publication, comprising a compilation of diverse studies on the nexus between climate change and extractive industries, seeks to propose strategies on how extractive industries can take meaningful action related to climate change mitigation and adaption measures along their production chain.

Anja Berretta

Director Regional Programme Energy Security and Climate Change in Sub-Saharan Africa, Konrad-Adenauer-Stiftung

Abbreviations and Acronyms

AAAS	-	American Association for the Advancement of Science
AARES	-	Australian Agricultural and Resource Economics Society
AAS	-	Australian Academy of Science
ACET	-	African Center for Economic Transformation
ACPC	-	Africa Climate Policy Centre
ADES	-	Asociación de Desarrollo Económico Social
AfDB	-	African Development Bank
AFOLU	-	Agriculture, Forestry and Other Land Use
AGENDA	-	AGENDA For Environment and Responsible Development
AIPP	-	Asia Indigenous Peoples Pact
AMDC	-	African Minerals Development Centre
AMWUZ	-	Associated Mine Workers Union of Zimbabwe
AR5	-	Fifth Assessment Report
ARD	-	Associates in Rural Development
ASGM	-	Artisanal and Small-Scale Gold Mining
ASM	-	Artisanal and Small-Scale Mining
AU	-	African Union
AVG	-	Alliance Voahary Gasy
BHEC	-	Beijing Huayu Engineering Company
BNC	-	Bindura Nickel Corporation
CBDR	-	Common But Differentiated Responsibilities
CCRP	-	Climate Change Response Plan
CCRS	-	Climate Change Response Strategy

CCTEG	-	China Coal Technology & Engineering Group
CDM	-	Clean Development Mechanism
CEPA	-	Centre for Environmental Policy and Advocacy
CIPs	-	Core Investment Priorities
CNRG	-	Centre for Natural Resource Governance
CO_2	-	Carbon Dioxide
COMESA	-	Common Market for Eastern and Southern Africa
COPs	-	Conferences of Parties
CPGU	-	Cellule de Prévention et Gestion des Urgences
CSA	-	Climate-Smart Agriculture
CSIRO	-	Commonwealth Scientific and Industrial Research Organisation
CSO	-	Civil Society Organisation
CTCN	-	Climate Technology Centre and Network
DRC	-	Democratic Republic of Congo
EIA	-	Environmental Impact Assessment
EITI	-	Extractive Industries Transparency Initiative
ELAW	-	Environmental Law Alliance Worldwide
EMAPE	-	Exploitation Minière Artisanale et à Petite Echellle
EMP	-	Environmental Management Plan
EOLSS	-	Encyclopedia of Life Support Systems
EPA	-	Environmental Protection Agency (United States)
EPCM	-	Engineering, Procurement, Construction and Management
EPP	-	Environmental Protection Plan
ESIA	-	Environmental Social-Impact Assessment
ESMP	-	Environmental social Management Plans
EV	-	Electric Vehicle
FAO	-	Food and Agriculture Organization
FCPF	-	Forest Carbon Partnership Facility

FDI	-	Foreign Direct Investment
FEMATA	-	Federation of Miners Associations of Tanzania
FES	-	Friedrich-Ebert-Stiftung
FREL	-	Forest Reference Emission Level
GCF	-	Green Climate Fund
GDP	-	Gross Domestic Product
GEF	-	Global Environment Facility
GEREMA	-	Geita Regional Miners Association
GHEITI	-	Ghana Extractive Industries Transparency Initiative
GHG	-	Greenhouse Gases
GIZ	-	Gesellschaft für Internationale Zusammenarbeit
GoM	-	Government of Malawi
IAIA	-	International Association for Impact Assessment
IBA	-	International Bar Association
ICAD	-	Initiative for Climate Action and Development
ICAT	-	Initiative for Climate Action and Transparency
ICESCR	-	International Covenant on Economic, Social and Cultural Rights
ICMM	-	International Council on Minerals and Metals
ICSC	-	International Centre for Sustainable Carbon
IEA	-	International Energy Agency
IGF	-	Intergovernmental Forum
IISD	-	International Institute for Sustainable Development
ILA	-	International Law Association
ILO	-	International Labour Organisation
IMF	-	International Monetary Fund
INDC	-	Intended Nationally Determined Contribution
INRA	-	Institute for Natural Resources in Africa
IPCC	-	Intergovernmental Panel on Climate Change

IPPs	-	Independent Power Producers
IPPU	-	Industrial Processes and Product Use
IPRs	-	Intellectual Property Rights
IRENA	-	International Renewable Energy Agency
ITCZ	-	Inter-Tropical Convergence Zone
LDC	-	Least Developed Countries
LEDS	-	Low Emission Development Strategies
LPG	-	Liquefied Petroleum Gas
LULUCF	-	Land Use and Land-use Change
MCCCI	-	Malawi Confederation of Chambers of Commerce and Industry
M-CLIMES	-	Modernised Climate Information and Early Warning Systems
MCM	-	Madagascar Consolidated Mining
MCP	-	Mean Class Proportion
MEEF	-	Ministry of Environment, Ecology and Forests (Madagascar)
MESTI	-	Ministry of Science Technology and Innovation
MGDS	-	Malawi Growth and Development Strategy
MoFEPD	-	Ministry of Finance, Economic Planning and Development [Malawi]
MPRA	-	Munich Personal RePEc Archive
MRV	-	Monitoring Review and Verification
NAMAs	-	Nationally Appropriate Mitigation Actions
NAP	-	National Adaptation Plan
NAPA	-	National Adaptation Programmes of Action
NCCARF	-	National Climate Change Adaptation Research Facility
NCCMP	-	National Climate Change Management Policy
NCCS	-	National Climate Change Strategy
NDC	-	Nationally Determined Contributions
NDP	-	National Development Plan

NEPAD	-	New Partnership for Africa's Development
NMVOCs	-	Non-Methane Volatile Organic Compounds
NMWUZ	-	National Mine Workers Union of Zimbabwe
NTCCC	-	National Technical Committee on Climate Change
ODI	-	Overseas Development Institute
OECD	-	Organisation for Economic Cooperation and Development
OHS	-	Occupational Health and Safety
OSCIE	-	Organisation de la Société Civile sur les Industries Extractives (Civil Society Organisations Platform on Extractive Industries)
PA	-	Paris Agreement
PER	-	Potchefstroomse Elektroniese Regsblad (Potchefstroom Electronic Law Journal)
PGMs	-	Platinum Group of Metals
PML	-	Primary Mining Licence
PNDC	-	Provisional National Defence Council
PPC	-	Pretoria Portland Cement
PPPs	-	Public-Private Partnerships
RBA	-	Risk-Benefit Analysis
RBM	-	Reserve Bank of Malawi
RCMs	-	Regional climate models
RCPs	-	Representative Concentration Pathways
REDD	-	Reducing Emissions from Deforestation and Forest Degradation
REDD+	-	Reducing Emissions from Deforestation and Forest Degradation (plus stands for countries' efforts to reduce emissions)
REEs	-	Rare Earth Elements
RIMES	-	Regional Integrated Multi-Hazard Early-warning System
RIRDC	-	Rural Industries Research and Development Corporation
RISDP	-	Regional Indicative Strategic Development Plan

SADC	-	Southern African Development Community
SADC-CNGO	-	SADC-Council of Non-Governmental Organisations
SAPS	-	South African Police Service
SAPs	-	Structural Adjustment Policies
SARW	-	Southern Africa Resource Watch
SASB	-	Sustainability Accounting Standards Board
SDGs	-	Sustainable Development Goals
SERAC	-	Social and Economic Rights Action Centre
SHE	-	Safety Health and Environment
SIF	-	Solidarité des intervenants du foncier
SSA	-	Sub-Saharan Africa
STEPS	-	Social, Technological and Environmental Pathways to Sustainability
TAWOMA	-	Tanzania Women in Mining Association
TEC	-	Technology Executive Committee
TI-IM	-	Transparency International – Initiative Madagascar
TMA	-	Tanzania Meteorological Authority
TNAs	-	Technology needs assessments
TSFs	-	Tailings storage facilities
UBC	-	University of British Columbia
UNCED	-	United Nations Conference on the Environment and Development
UNCHE	-	United Nations Conference on the Human Environment
UNCTAD	-	United Nations Conference on Trade and Development
UNDP	-	United Nations Development Programme
UNECA	-	United Nations Economic Commission for Africa
UNEP	-	United Nations Environment Programme
UNESCO	-	United Nations Educational, Scientific and Cultural Organization

UNFCCC	-	United Nations Framework Convention on Climate Change
UNGA	-	United Nations General Assembly
UNU	-	United Nations University
USAID	-	United States Agency for International Development
USD	-	United States Dollar
USGS	-	United States Geological Survey
WBGT	-	Wet Bulb Globe Temperature
WCED	-	World Commission on the Environment and Development
WIDER	-	World Institute for Development Economic Research
WSSD	-	World Summit for Sustainable Development
WTO	-	World Trade Organization
WWAP	-	World Water Assessment Programme
WWF	-	World Wildlife Fund
ZAM	-	Zambia Association of Manufacturers
ZCCM	-	Zambia Consolidated Copper Mines
ZCTU	-	Zimbabwe Congress of Trade Unions
ZEPARU	-	Zimbabwe Economic Policy Analysis and Research Unit
ZESA	-	Zimbabwe Electricity Supply Authority
ZIDAWU	-	Zimbabwe Diamond Workers Union
ZIMASCO	-	Zimbabwe Mining and Smelting Company

Introduction

Dr. Claude Kabemba and Veronica Zano

Climate change has arguably become one of the biggest challenges facing humanity. It is also the most urgent issue that requires global solutions. The increase in greenhouse gas (GHG) emissions continues despite the Paris Agreement of 2015. Higher temperatures, rising sea levels and more extreme weather patterns are becoming permanent across different geographical regions. The African continent has not been spared where climate-induced weather hazards in the form of severe droughts and more intensive cyclones are causing devastating effects on society, environment and economies of countries on the continent already battling infrastructure, social services and food security challenges amongst many others.

There is consensus around the world that climate change is primarily due to human activities, particularly those that emit carbon dioxide into the atmosphere. The extractive industry has been classified as amongst the key economic sectors that emits a substantial amount of carbon dioxide. This is due to the sector's extremely energy-intensive processes.

Except for the coal industry in South Africa, there are not many studies that look at the nexus between climate change and extractive industries on the continent. The continent is a top producer of the world's fossil fuels (oil, gas and coal). Exploited mineral reserves include platinum group of metals (PGMs), diamonds, gold, chromium, cobalt, uranium, bauxite, vanadium and manganese. Africa supplies these commodities to developed and industrialised economies without value addition. With all these mineral reserves, Africa is therefore supporting the industrialised world to achieve and contribute towards climate action. While the move to a lower-carbon future is dependent on the production of strategic minerals and metals, the extractive industry in Africa is not fulfilling its much-expected role of poverty reduction and sustainable development. However, little is known on the efforts governments, the private sector and regional economies are deploying to limit the impact of the extractive sector on climate change.

This publication systematically discusses the relationship between climate change and extractive industries in sub-Saharan Africa. It looks at different aspects (technology, legislations and policies, economic taxation, human rights) at country and regional levels, as well as large-scale mining, artisanal and small-scale mining operations (ASM). From the various contributions, it has become clear that the extractive industry is a game changer in the discourse of climate change reduction and adaptation given the nexus between the two. Climate change impacts the extractives industry sector in several ways, generating both threats and opportunities. However, this nexus is hardly articulated in the context of its implication on sustainable development and climate change mitigation on the African continent. This nexus produces positive and negative effects for the governments, mining industry actors and the Africa population depending on the actions that are taken. The positive nexus occurs when sustainable extractive processes and initiatives are employed by the extractive industry, which help towards reducing carbon emissions. The negative nexus happens when unsustainable extraction processes are fostered in the sector, undermining efforts to reduce climate change.

1
Climate Change and Sustainable Development: Impact of the Extractive Industries in Malawi

Peter J Glynn, Gift Maloya and Amos Banda

Abstract

This paper explores the impact of climate change in Malawi and the responses by the government. It then examines the impact of these responses to the extractive industry in the country. The research applies a mixed-methods approach of literature review and survey of stakeholders. Malawi is an emerging agrarian economy confronted by issues of poverty, inequality, and food and water insecurity. It is experiencing extreme weather events that have disturbed the balance of its economic base that required immediate interventions from the government with the support of external agencies. This research seeks to establish if and how the extractive industries are contributing to the problems and what measures are required to counter that contribution. The nexus between extractive industries and climate change policies in Malawi is at best not material and in practice does not exist; rather they are issues developing in parallel. The government has developed a comprehensive and appropriate climate change management policy and with a readiness to adapt. As the extractive industries emerge as an important economic sector, the governance arrangements are in place to ensure the industry is climate change compliant.

Introduction

Malawi is a largely agrarian economy with many people reliant on subsistence farming and hence live in poverty. The changing climate and the accompanying erratic weather patterns impact heavily on the country's rural and urban communities (Malawi, 2015). Whether acknowledging the urgency of its domestic situation or honouring its commitments to international and regional climate change undertakings, the Government of Malawi adopted a comprehensive National Climate Change Management Policy (NCCMP) in 2016 (NCCMP, 2016). This policy, with the complementary Implementation, Monitoring and Evaluation Strategy, is guiding the interventions to enhance the resilience of productive sectors to the associated negative impacts. This study explores the impact of climate change in Malawi and across the Southern Africa region. It addresses the rationale that underpins the NCCMP, with particular focus on the extractive industries sector as well as the sector's nexus to climate change and policy responses.

Malawi's extractive industries and climate change

Malawi is a landlocked and densely populated country located in Sub-Saharan Africa. The country's total area is 118,484 square kilometres with an estimated population of 17 million (World Bank, 2017), growing at an annual rate of 2.8 percent. Malawi's per capita income (expressed from the gross domestic product or GDP) in 2021 was USD 272. Incidents of adverse weather have affected agricultural production and were expected to constrain domestic demand and activities in the manufacturing sector. The resultant shocks included flooding in the southern parts of the country, the late onset of rains in most parts of the country, dry spells in the central and northern regions, and the early cessation of rain for late-planted crops.

Climate-sensitive rain-fed agriculture is the mainstay of Malawi's agro-based economy (Malawi, 2015). It accounts for 30 to 40 percent of the country's GDP, employing 85 percent of the workforce and supplying 60 to 70 percent of raw materials to the manufacturing sector. In its 2015 Nationally Determined Contribution (NDC) submitted to the United Nations Framework Convention on Climate Change (UNFCCC), the government of Malawi reported that, because of the country's vulnerability to climate change, there was an urgent need to undertake interventions to enhance the resilience of productive sectors to associated negative impacts.

Malawi is an undiversified economy, which, apart from facing serious challenges in 2011 and 2012, has been relatively resilient (OECD, 2013). Progress had been made in tackling poverty and other social challenges apart from the problems of food security, universal primary education, gender equality and women's empowerment and improving maternal health (OECD, 2010). In its most recent Annual Economic Report the government projected "real GDP growth of 5.1% that will be driven by Agriculture; Manufacturing; Mining and Quarrying; Electricity, Gas and Water; Information and Communication; and Financial and Insurance Services" (Malawi 2019a, p. 7). Although the extractive industries contributed less than 1 percent to GDP in 2019, the government remained positive about the prospects for the sector.

All climate activities are anchored in statute. These are supported by a range of policy instruments that have emerged from the government's Malawi Growth and Development Strategy (MGDS), currently in their third cycle, known as MGDS III. The principal relevant policy instruments related to climate change are the 2016 National Climate Change Management Policy with its companion, the Implementation Strategy. For the extractive industries, the key policy instruments are the Mines and Minerals Policy (Malawi, 2013) and the Artisanal and Small-Scale Mining Policy (Malawi, 2014),

Despite the government's optimism and the private sector, and an initial surge in investment and the economic return of 9 percent of GDP, the extractive sector has failed to maintain momentum and is now contributing less than 1 percent to the GDP. Paradoxically, there has been little change in employment in the sector, with the majority of employment in the stable rock aggregate sector, and the informal workforce of artisanal and small-scale mining. Over the same period, the government stepped up its policy and strategy interventions across the economy and communities in its efforts to manage the impact of climate change. In 2020, the respective circumstances meant the contribution of the extractive sector and climate change strategies were running in parallel rather than intersecting. That said, there is little doubt that the country's vast natural reserves in coal, uranium and rare-earth minerals will reward the patience of government and investors over the longer term. The measures being put in place, coupled with the environmental and climate strategies, will deliver a sustainable extractive sector that meets domestic and international environmental, social and economic objectives.

Malawi's commitments to climate change

Malawi, like most countries in Africa, and particularly sub-Saharan Africa (SSA), has experienced the direct consequences of global warming that is already occurring and continues to escalate, adversely impacting food security, water quality and energy security, and frustrating government efforts to improve the general livelihoods of both urban and rural communities. The Malawi policy response, the National Climate Change Management Policy (2016) has been developed and designed within the context of these development priorities, and in accordance with its international and regional undertakings.

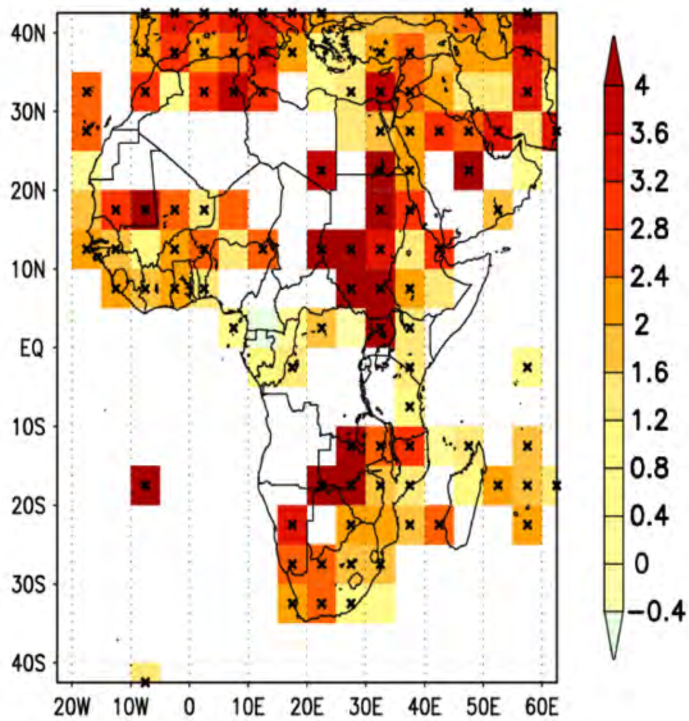


Fig. 1.1. Observed trends in annual average temperature over Africa, 1960- 2010. *(**Sources:** Engelbrect et al (2015); Garland et at. (2015).*

The Intergovernmental Panel on Climate Change's (IPCC) recent workshop in Ghana (IPCC, 2019) provides a valuable insight into the trends in climate change impacting the continent and regions essential data for governments in the development of further policy responses. The charts below are from presentations at the workshop and, interestingly, demonstrate the diversity of the trends in temperature and rainfall changes across the continent, reaffirming that there is not one policy package that can be applied; all regions and countries, even within countries, have unique experiences requiring tailored responses.

For the Southern Africa region, temperature increases are already measured at above 1°C and in some instances as high as 4 degrees Celsius. For SSA, the temperature increase ranges from 0.5°C to 3.5°C. For Malawi, the range is 1.5 to 3°C. The Figure 1.2 demonstrates the varying impacts on rainfall and water availability, which it simply summarises as "Africa at heavy risk".

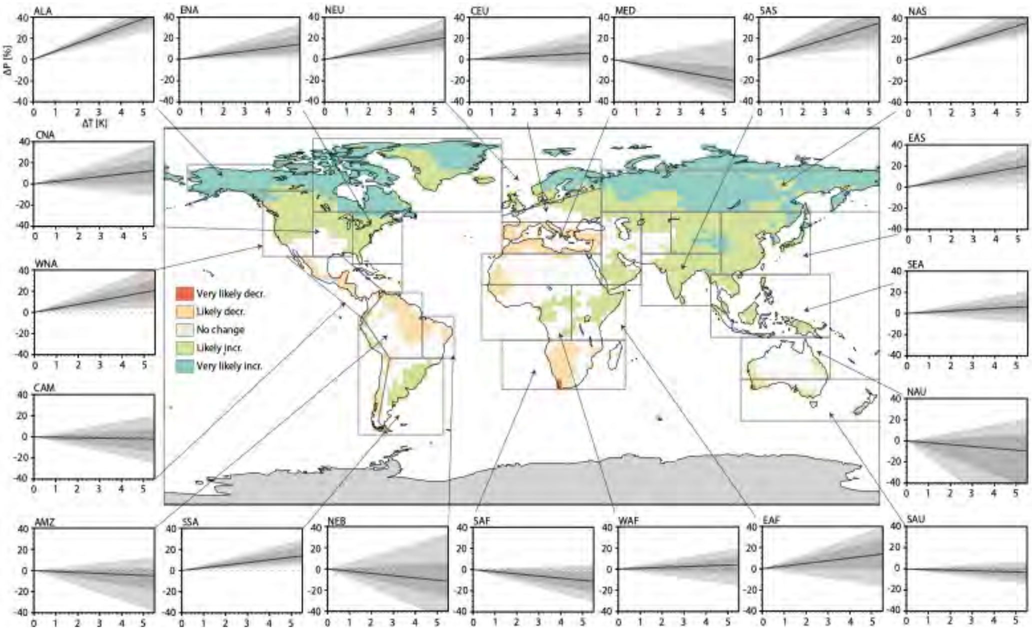


Fig. 1.2. Differences in regional impact: Africa at heavy risk. *(**Source**: Masson-Delmotte, V., Zhai, P., Pörtner, H-O., Roberts, D., Skea, J., Shukla, P.R. et al. (2019). Global warming of 1.5°C: An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty: 212. Intergovernmental Panel on Climate Change.)*

For the agrarian economies, policies are producing positive results in the indicators of decent work and economic growth, innovation and infrastructure, sustainable communities, peace and strong institutions. However, health and wellbeing and affordable energy remain problematic. Overall, it can be said that, while progress is being made and government's approach to climate action is generally appropriate, education, gender and inequality remain problem issues. In the Malawi context, its national development priorities and the NCCMP reflect the importance the government attaches to each of these indicators and its strategies to deliver improved outcomes.

Malawi is well represented in regional authorities and planning. The country's commitments are reflected in the period covered by the three successive MGDS, which specifically state the government's commitments to the Pan African Vision of Aspirations (UN, 2015), the Vienna Programme of Action (UN, 2016), the Istanbul Programme of Action (UN, 2011), the Southern African Development Community (SADC) Regional Indicative Action Plan (RISDP, 2012) and the COMESA Treaty (COMESA, 1993). The commonality of purpose across these authorities and instruments is that cooperative action benefits each member country and provides guidelines for action through the exchange of best practices.

Although couched in the specific "reason for being" of each, there is a commonality among the higher-order principles that conveys the significance attached to stability in the region to ensure the independence and the accommodation of the unique domestic circumstance of each country. Common among those higher-order principles is peace and security, cultural identity and cross-border cooperation, and commitment to international treaties such as the SDGs and the Paris Agreement.

The SADC Climate Strategy and Action Plan (SADC, 2015) approach of a long-term plan with five-year review and planning cycles provides a well-structured set of guiding principles and strategies, much of which is reflected in the Malawi NCCMP. Its Sector Specific Strategic Interventions of agriculture, water, biodiversity, fisheries, health, settlements, tourism and mining were not addressed specifically by the IPCC Ghana Workshop. Instead, the IPCC spoke in terms of multisector risks under shared socio-economic pathways, which it identified as water stress, heatwave event exposure, hydro-climatic risk to power production, crop yield change and habitat degradation. While its proposals in respect of adaptation are already reflected in the Malawi plans, the IPCC Workshop drew particular attention to the incidence of rapid urbanisation, the need for urban planning, the urban population living in informality and city governance, issues which as yet are not satisfactorily addressed in the Malawi NCCMP and which possibly merit further detailed consideration in the next SADC climate strategy planning cycle.

The impact of climate change on the continent and the region as well as the dependence on agriculture are influencing the delivery of commitments to the SDGs. The commitments of the SADC and its member countries is not questioned, but their socio-economic circumstances challenge their ability to make significant progress. As an introduction to the climate situation in Malawi, the initiative of the South African government merits mention. The South African National Planning Commission (South Africa, 2019) was created by the country's parliament in 2012 and was tasked with producing the National Development Plan (NDP). The commission's plan, "Ensuring Environmental Sustainability and an Equitable Transition to a Low Carbon, Climate Resilient Economy and Society" (Chapter 5 of the plan) adopts the target that, by 2030, South Africa will have transitioned to an environmentally sustainable, climate-resilient, low-carbon economy and just society.

In 2018, the NPC commenced Social Partner Dialogues on Pathways for a Just Transition in 2018. The aim was to build consensus on a common vision for a just transition to a low-carbon, climate-resilient economy and society by 2050 and to develop proposals for pathways to achieve this vision. The process was significant because of its declared commitment to engage with stakeholders. Recent research by Climate Strategies (Glynn et al., 2020) found that government engagement with stakeholders in the development of climate strategies was the exception rather than the rule for developing and least-developed countries. That research also found stakeholder engagement was essential in the effective development and delivery of climate change policies by the government.

The NPC engaged with stakeholders through a series of dialogues with civil society and the business, government, labour and experts communities. It reported this work to a July 2020 webinar seeking feedback: that the process began with a high-level social partner dialogue and progressed to workshops in each province as well as engagements with various constituencies, such as the youth and labour and business communities through bilateral meetings, roundtables and a concluding conference on 29 May 2020. The NPC adopted an economy-wide scope for planning for a just transition in South Africa, with three key sectors, namely energy, water and land use, being prioritised since they continue to underpin the contribution, impact and vulnerability of South Africa to climate change, besides poverty and inequality.

An important element in the outcomes was an agreement by stakeholders that the starting point would be to put the strategic objectives of addressing poverty, inequality and unemployment at the heart of the transition. As was reported by Climate Strategies from its research, it is, "the lack of consensus around the meaning and implications of the just transition concept that is creating a barrier to its understanding, acceptance and introduction into policy" (Glynn et al., 2020, p. 1)).

The South African NPC, unlike many developing and least developed countries, recognises and adopts the objective of the 1992 UNFCCC, (1992), which acknowledges that climate strategies should take into account economic, social and environmental impacts, as does the Paris Agreement (UN, 2015). The Government of Malawi, through its NCCMP (2016) also gives effect to the UNFCCC objectives of the United Nations Conference on the Environment and Development (UNCED) and the Paris Agreement.

MGDs have been the Malawi government's initiative guiding, among others, the creation and implementation of its 2016 NCCMP. The MGDS are now in their third phase, starting in 2006. MGDS III is the government's overarching long-term strategy for Malawi, designed to attain its development aspirations. It follows the successful implementation of the country's medium-term strategy (MGDS II), which it reports registered progress in a number of areas including high economic growth, declining poverty levels, strong donor support, increased foreign direct investment and transformation in infrastructure (Malawi, 2017).

The objective of MGDS III is to move Malawi to a "productive, competitive and resilient nation through sustainable agriculture and economic growth, energy, industrial and infrastructure development while addressing water, climate change, environmental management and population challenges" (Malawi, 2017, p. xvi) and is aligned to its international, continental and regional obligations. MGDS III has the following five key priority areas: agriculture, water development and climate change management; education and skills development; transport and ICT infrastructure; energy, industry and tourism development; and, health and population. The MGDS III report of the Social Context is that, although progress has been made, poverty and inequality remain high. It attributes this dynamic to the following factors: low productivity in the agriculture sector; limited opportunities for non-farm activities; volatile economic growth; rapid population growth; and, limited coverage of safety-net programmes. Alarmingly, it observes that these are "targeting challenges which do not align to national development priority areas".

The MGDS and international and regional commitments provide the guide to the legislative and policy framework of the Malawi Government. The government has then tailored them to serve its unique economic and social circumstances. The following statutes provide the basis for enforcement of the MGDS and the NCCMP:

- The Constitution of the Republic of Malawi (1995)
- Environment Management Act (2017)
- Malawi National Environmental Action Plan (2002)
- National Environmental Policy (2004)
- Guidelines for Environmental Impact Assessment (EIA) (1997)
- National Forest Policy (2016)
- National Forest Landscape Restoration (NFLR) Strategy (2016)
- Water Resources Act (2013)

Furthermore, the Nationally Determined Contribution submitted to the UNFCCC is an authoritative enforceable commitment under the Paris Agreement.

As has been demonstrated in the discussion above, the countries of the South African region have developed a strong and complementary platform of support and high-level guidance for member countries. The following section discusses the situation and process of how Malawi is extending this cooperation into its policies and approach to the extractive-industries sector and climate change.

Malawi's state of extractive industries

The Malawi Extractive Industries Transparency Initiative (MEITI) has described the extractive industries in Malawi as:

> *... large mineral deposits with economic potential, such as Phosphates (apatite); Bauxite; Kaolinitic clays; Coal; Kyanite; Limestones; Rare Earths (including Strontianite and Monazite); Graphite; Sulphides (Pyrite and Pyrrhotite); Iron ore; Titanium minerals; and Vermiculite. Most of these minerals have been evaluated*

in the past by either the Geological Survey Department or private companies. Only gemstones, phosphate, coal, limestone, and uranium have been exploited. In addition, rock aggregate is exploited in many parts of the country for the construction industry (BDO, 2019, p. 22).

The contribution of the mining sector to Malawi's GDP, as measured by the Reserve Bank of Malawi (RBM, 2020), and to employment, as measured by the Ministry of Finance, Economic Planning and Development in their annual economic reports (Malawi, 2009-2019) is reflected in the following Tables 1.1 and 1.2.

***Table 1.1**.* Contribution of the mining sector to Malawi's GDP.

Reserve Bank of Malawi Volumes 46-54. Charts: Percentage Sectoral Contribution to GDP											
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Agriculture, forestry and fishing	29	31	30	33/30*	34/30*	29	28	27	27.5	27	22
Wholesale and retail trade	16	16.5	17	18/15*	19/15*	15	15	19	18	18	16
Construction	3	3	3	3	3	3	3	3/8*	2.5	2.5	2.5
Manufacturing	9.5	10	10	10.5/9	8.5	9	8	7	8	8	8
Mining and quarrying	4	4	5	5.5/0.5	6/0.5*	0.5	1	2	>1	>1	>1
Real estate activities	8	8	8.5	8.5	9	7.5	7	>1	6	6	6
Information and communication	3.5	3.5	4	4.5	5	405	4	5/1*	5/1*	4.5/1*	5/1*
Finance and in.surance	4.5	5	5	5	6	5	5	>1	5/1*	5/1*	5/1*
Transport and storage	2	2.5	205	3	2.5	2.5	2.5	2.5	3	3	3
Accommodation and food service activities	2	2	2	2	2	1.5	2	2	2	2	2
Electricity, gas and water supply	2	2	2	2	2	1.5	1	1	1	1	1
Mining and quarrying	4	5	6	7	1	1	1	1	1	1	1
Public administration and defence	3	3	3	3.5	3.5						

* RBA 2020

Table 1.2. Mining sector workforce.

Malawi Government Annual Economic Reports 2010-2019. Mining sector employment												
	2008	2009	2010	2011	2012	2013	2014	2015	2016*	2017	2018	2019
Coal	1100	N/A	N/A	N/A	671	637	606	580	520/621*	650	715	1122
Uranium		N/A	N/A	N/A	740	703	300	197	193/179*	179	179	142
Quarry and aggregate production	2030	N/A	N/A	N/A	9024	8573	8144	9200	9025/9582*	9650	9672	9691
Gemstones	176	N/A	N/A	N/A	130	124	117	220	250/343*	380	473	506
Minerals exploration		N/A	N/A	N/A	186	177	168	160	175/238*	300	532	728
Minerals production		N/A	N/A	N/A	930	884	839	710	680/1012*	1100	1147	1156
Cement lime / manufacturing	96	N/A	N/A	N/A	112	106	101	148	155/1295*	1500	1557	1569
Agricultural calcitic and hydrated lime	194	N/A	N/A	N/A	1765	1677	1593	1832	1920/1943*	2050	2097	2105
Cement lime	348	N/A	N/A	N/A								
Ornamental stones	37	N/A	N/A	N/A	32	30	29	35	40/44	70	79	83
Clay/pottery	125	N/A	N/A	N/A								
Terrazzo	176	N/A	N/A	N/A	60	57	54	58	60/105*	150	146	138
Other	538											
Sector total	4850	11565			13650	12968	11951	13140	13018/ 15362*	16029	16592	17240
**Total workforce	5693	5865	6049	6241	6450	6673	6887	7106	7334	7563	7799	8079
% of total workforce	0.09	0.20	0.00	0.00	0.21	0.19	0.17	0.18	0.21	0.21	0.21	0.21

*Annual Economic Reports 2016 and 2018

** ILOStats

As the above tables show, after peaking at 6 percent in 2014, the contribution of the mining sector to GDP dropped to less than 1 percent in 2020 and, except for quarry and aggregate production, the contribution to employment is at best modest, at 8079 in 2019. That said, “the number of people who are self-employed in the mining sector, especially small-scale operators, is over 20,000. It is generally difficult to get the actual number of artisanal and small-scale miners since most of these operate in remote areas and are unregulated” (BDO, 2019, p. 51).

Extractive sector legislative framework

Mining activities in Malawi range from artisanal and small-scale mining to medium- and large-scale mining. All are regulated sectors, although small-scale mining is often undertaken outside the authority of formal employment and regulated reporting (Malema, 2017). Artisanal and small-scale mining are typically practised in the most remote rural areas of Malawi by a population with few employment alternatives and are generally carried out through labour-intensive methods for limestone, clay for pottery and gemstones.

Participants in the industry are subject to the following statutory instruments: The Explosives Act 1968; Mines and Minerals Act 2019; Petroleum (Exploration and Production) Act 1993; and, the Atomic Energy Act 1996. Small-scale mining is facilitated by mining permits, mining claim licences and reserved mineral licences. Policy instruments in force in the sector are the MGDS III, the Mines and Minerals Policy, the Artisanal and Small Scale Mining Policy, the African Mining Vision and the NCCMP and its strategic implementation plan. As employers, mining companies must also comply with the Labour Relations Act No 16 of 1996, Occupational Safety, Health (OSH) and Welfare Act No 21 of 1997, Employment Act No 6 of 2010, Workers Compensation Act No 7 of 2000, and the Pension Act No 11 of 2011. However, and as has been noted previously, the informal workforce operates outside this regulation and remains the largest workforce in the sector.

In its review of the sector in 2016, the Malawi Centre for Policy and Advocacy observed the ongoing efforts by the government and other key stakeholders to help in enhancing operations and dealings of the extractive industry and ensuring that they are performed through sound legislation that promotes human rights, transparency, accountability and equity. However, it then concludes that the sector-policy and regulatory frameworks at the time were archaic, and may not speak to the regional mining vision or the expectation of a modern society (CEPA, 2016). Most have now been revised.

Extractive sector governance: Extractive Industry Transparency Initiative

This section of the research has relied on the Extractive Industry Transparency Initiative (EITI) audit of 2017 (BDO, 2019) of the sector in Malawi and the stakeholder survey conducted in 2020. The EITI is formed by a consortium of governments that commit to an external review of their activities in the extractive sector against an international audit standard. The survey critique of the sector derives from its survey of 20 stakeholders from government, businesses, trade unions, artisanal and small-scale miners, and civil society, including gender groups. The survey provides a contemporary data source that is otherwise not generally available.

EITI was first announced at the World Summit for Sustainable Development in Johannesburg in 2002 (the 'Earth Summit 2002'). The Initiative is a global coalition of government agencies, extractive companies and civil society organisations working together to improve openness and accountable management of revenues from natural resources. EITI therefore promotes better governance in countries that are rich in oil, gas and mineral resources (BDO, 2019, p. 9). The objective of the EITI report is to help in the understanding of the level of contributions of the extractive sector to economic and social development in order to improve transparency and good governance at all levels of the extractive-industry value chain.

The EITI 2019 report for Malawi describes the sector as characterised by low levels of mining and low-value industrial, semi-precious and energy minerals. Even so, the government aims to improve the mineral sector's contribution to GDP through the development of a functioning institutional setting to promote mining, ensuring compliance by small-, medium- and large-scale miners with environmental and safety standards, supporting small-scale miners by integrating them in the minerals market and increasing their value addition, and increasing investment by private-sector companies in medium- and large-scale mining.

While clinical in its reporting and the overall positive nature of the investigation's findings, it also reports gaps in governance that are significant, identifying the need for the disclosure of contracts and agreements, submission of data at a project level, follow up of non-tax payments, the accuracy of production data, data completeness, quality and assurance, accuracy and comprehensiveness (BDO, 2019). Malema (2017), in one of the rare academic peer-reviewed reports of the sector in Malawi, was similarly critical, describing the Mines and Minerals Act (now revised) as archaic, and recommending that the government should improve the enforcement of laws and regulations.

The EITI audits are valuable but are limited to the issues of governance surrounding the economic and statutory matters of the sector. The Government of Malawi, through its annual economic reports and the limited public reporting by mining companies and non-governmental representative organisations, provides the essential insight into the related environmental governance issues, which are important to the national development priorities and goals, as stated in the government's MGDS and its goals for the management of climate change through the NCCMP.

Company websites, which are few, add some specifics to the reporting, particularly in respect of their corporate social responsibility. The Environmental Consultant (Mphande, 2019), engaged to undertake the environmental impact assessment for the RAK Gas MB 45 oil exploration proposal, observed that the company's focus was on people, land, water, animals, plants and air. The consultant added that "the people were more concerned about how the initial project would affect their lives and compensation. They were concerned with how the initial project would affect their marriages in fear of losing their wives to the project implementers". The Kaziwiziwi Mining Company (KMC, 2020) promotes its commitment to corporate social responsibility, announcing its support for local communities by providing infrastructure and staff, providing a high level of safety, and by its use of clean energy.

The most clinical independent report is provided in Malema (2017) in his research article on working conditions in the mining sector. He observes that working conditions and wages are generally poor, but, conversely, that a problem for trade unions and communities is over-expectation. He identified some social issues as inadequate empowerment of local people, lack of formally articulated social responsibilities for mining companies, disruption of families and social structures, child labour and compensation and resettlement of landowners and affected communities.

Extractive sector governance: stakeholder survey

The survey conducted for this research project provides the most up-to-date available qualitative data. The responses were revealing and, by-and-large, indicated the positive developments in extractive industry governance and the participation by the private sector, with the government's objectives through the MGDS and its sector policies. The survey was conducted by semi-structured interviews of all stakeholders in the extractive-industry sector. It was conducted by the Initiative for Climate Action and Development (ICAD), a Malawi NGO and partner in this research project. The summary of the stakeholder perspectives is presented below.

Government respondents revealed that, while the Ministry of Mining has the responsibility over, and is the custodian of, the sector's performance data, responsibility is shared with the Environmental Affairs Department for the administration of the environmental and social-impact assessments. It also ensures cohesion on compliance with environmental monitoring and the life cycle of mining. Responsibility for reporting is integrated across the Ministries of Mining, Forestry and Natural Resources, Finance, Economic Planning and Development, and the line departments and agencies. The government conducts periodic safety, health and environmental inspections and minerals and environmental sampling. There are also checks on environmental issues, such as waste disposal, and remediation of land when excavation is completed. It also collects workplace information on aspects such as number of workers, occupational health and safety procedures and records, wages and conditions.

The government contends that, although the extractives sector in Malawi is relatively small, it has the potential to make a significant contribution to economic growth and sustainable development. It has put in place the systems and procedures to ensure proper governance of the sector, but the departments are constrained by limited financial and human resources. Respondents suggested a further evaluation of the policy targets and additional departmental resources would provide a clear direction to the industry of the government's commitment to the implementation of programmes and industry's role in the delivery of national development plans and climate-responsive and sustainable economic growth and development.

Business respondents in the formalised extractive-industries sector were supportive of the government programmes and were working with the government to ensure their effective implementation. In practice, businesses report mostly on an annual basis and are subject to routine inspections and intermittent audits by government. They are required to collect and record safety, health, environmental compliance and waste-management data. Reports are also required for the workplace, the number of employees, occupational safety and health, wages and working conditions. In the established businesses with a longer-term presence in Malawi, there are best practices that are being observed. For the more recent entrants to the industry, some are still working on establishing well-structured procedures to ensure compliance with laws and regulations. It was also noted that few companies had websites to publish real-time information for stakeholders and public access.

The private sector in the extractive industry is moving cooperatively to conform to government statutory and policy requirements, with well-designed structures and linkages to policy, regulations and corporate social responsibilities. However, there are still gaps between community expectations and company standard practices.

Artisanal miner representative organisations advise and support miners in the exploration and selling of minerals. They also undertake consultancy work and industry assessments, provide capacity building for small-scale miners, and create market linkages. Although most artisanal miners are in the informal sector, they engage with the government through the Artisanal and Small-Scale Mining Policy (2018) and other policies under the Ministry of Mining, Ministry of Trade, and the Ministry of Forestry and Natural Resources. Though policies are in place, implementation is a challenge due to limited departmental budget and capacity. The consequence is inadequate policy implementation and inspections of activities at mining sites and more illegal mining, although this has a positive economic benefit for small-scale miners.

The miners summarise the contribution of the sector to the economy and communities as creating employment opportunities, improving livelihoods through income and food security, improving other sectors like agriculture through the availability of income, formation of cooperatives, and advocating capacity building and skills development for artisanal miners. Conversely, they contribute to environmental degradation. Their recommendations to counter illegal practices in the sector include licences to artisanal miners for the mining of gemstones, other precious minerals and alluvial gold for which deposits are at a low scale and the Malawi Reserve Bank buying gold and other precious minerals, as the only legitimate entity under the laws of Malawi, which would reduce the smuggling of minerals to other countries.

For artisanal miners working in the quarry sector, the focus in the survey responses was occupational health and safety and welfare concerns. They commented on the increase in accidents due to the use of unsafe and unregulated machinery, increases in respiratory diseases, and the lack of effective regulations by the government to protect the welfare of workers in the sector. These are valuable observations and, far from wanting to perpetuate the informal nature of their operations, they are requesting and are open to working with the government to formalise the sector and to increase investment, technology and skills development, and effective occupational health and safety monitoring.

Trade unions report that they are mostly not active in the workplace, since union representatives for most employers were regarded as troublemakers. However, they still considered their efforts effective because of their vigilance over compliance with laws and regulations and they provided forums for the workplace representatives to meet and develop negotiating skills and strategies. They argue that the industry would benefit from the training of management and worker groups to understand the trade unions' benefits to both employees and employers. Non-disclosure of benefits and financial contributions by the companies made it hard for the unions to negotiate based on productivity and where employers referred to the general labour law and standard wage or income procedures. They acknowledge the contribution by some companies to workers and communities; for example, the cement exploration and production in Kasungu had provided the surrounding communities with schools, employment and social cash transfer. They however say that this, unfortunately, is the exception rather than the rule.

With regard to gender organisations, Malawian women, apart from being household caretakers and farmers, are also involved in the exploration of different minerals, as artisanal miners. They face a number of challenges, which include the fact that women often do not get an opportunity for decision-making around mining issues, from exploration stage to marketing their mineral products, compared to their male counterparts. There were no favourable laws and regulations to safeguard their rights along the mining value chain. This includes less or limited women's representation in small-scale artisanal associations or groupings.

Another challenge with a gender lens is the lack of opportunities for women in this sector to access safety and protective gear and access to and use of mining information from companies and government.

For the environmental groups, of all the survey respondents, the groups were the most vocal about their limited influence over the activities of the sector. They complained that mining companies do not adhere to their recommendations, which they made on environmental and social-impact assessments conducted in the sector and complained about the limited funding to conduct effective awareness, research and regional peer learning. In saying that, they acknowledge that medium- and large-scale mining companies observe the government's requirements for environmental assessments and reporting and there is no indication of breaches of these requirements. With respect to their relations with the government, they commented there is inadequate room for their participation and involvement in mining policy formulation and decision-making processes, including the provision of feedback by the government.

Civil-society organisations observed that there is no clear link and corroboration of the policies in climate change and mining, but the government, non-governmental organisations and development partners are working on the linkages. A difficulty is that most of the emerging issues in the sector are addressed separately instead of adopting a holistic approach. They also believe the MGDS III targets and actions need to be reassessed because the mining sector is not identified separately as a priority area, like climate change in the course of the country's development and sustainable development.

The survey provides a valuable insight, which is largely positive, about the initiatives of the government and private companies, although the lack of funding and skilled personnel constrains efforts to fill the governance gaps. Both the MEITI audit report of sector governance and the ICAD survey of stakeholder perspectives reflect significant positive progress by the sector. While there remain gaps that must be addressed, the audit report and the survey have established that the government's suite of policy initiatives for the sector, climate and the environment are being implemented. To the extent that the extractive industries contribute to climate change in Malawi, their activities are moving progressively towards accord with the government's ambition and targets. That said, it is not possible to overlook the extent of informal activities that are operating outside this framework and that gender and occupational health and safety remain key social development problems.

In summary, the industry has declined from a major to an almost inconsequential contributor to economic activity. Much of the industry's activity is in the small-scale informal sector, which also is the majority employer. The government and the sector are working cooperatively towards optimising the benefits that each can contribute. The industry has access to considerable mineral reserves that, with the efforts of the government to improve governance and create investment opportunities, will be ready to respond as global demand improves.

The environmental consequences of the extractive industries are also being addressed. The climate change dimension is, at this time, a relatively minor consideration, with little present impact, but, as a rapidly developing economy, with a rapidly urbanised population and the export potential of its coal, uranium and rare mineral resources, require the nexus to be acknowledged and the policies and strategies for each integrated.

The impact of climate change on the economy in Malawi

Major climate related hazards that wreak havoc in the country are floods and droughts; for example, in 2015, floods affected 15 out of the 28 districts in Malawi and a population of about 1.1 million people out of which 230,000 were displaced, 176 were killed and 172 were reported missing. The total cost of loss and damage that the Government of Malawi incurred during these severe floods was estimated to be USD 335 million, and the recovery and reconstruction costs stood at USD 494 million (UN, 2015). The increasing prevalence of the recurrent floods and droughts is of major concern to the government because of their far-reaching consequences on food, water, health and energy. Erratic rains have resulted in acute crop failure, despite concerted efforts to improve seasonal weather forecasting at the beginning of the rainy season. Crop failure has resulted in food insecurity and malnutrition, especially among vulnerable rural communities. Floods have also resulted in the disruption of hydroelectric power generation, water pollution and increased incidence of diseases such as malaria, cholera and diarrhoea (UNDP, 2020).

Malawi is a largely agrarian-based economy for which climate change has clearly had an impact. The Reserve Bank of Malawi's reports of the sectoral contribution to GDP show that, since peaking at 34 percent in 2014, the agricultural sector's contribution has declined each year to 22 percent in 2020 (RBM, 2020). Despite this trend, the government's 2019 annual economic report (Malawi, 2019) reported improved performance for agriculture, fishing and forestry. Its strategies have included improved crop practices and improved use of inputs such as fertilisers, an increase in livestock production attributed to good management practices, improved aquaculture practices and tree planting.

The government's commitments through its NDC for emission reduction will be concentrated in the key sectors of forestry, agriculture and energy, through programmes that are reported in its Implementation, Monitoring and Evaluation Strategy for the NCCMP (2016). The priority is in the following areas: adaptation; mitigation; education, training and awareness; research and development; and, finance. It identifies, as cross-cutting issues, legislation, population, gender and disadvantaged groups, and private sector and community participation. As has been mentioned throughout this text, the government is making solid progress in each of these areas.

The NCCMP has been developed and designed within the context of national development priorities. The principles include the protection of human rights, gender equality, sustainable development, equitable development, the polluter pays, the precautionary and informed stakeholder and community participation. The policy is a product of extensive consultations with the government, civil society, academia, NGOs, the private sector and development partners. District consultations were carefully selected through a consultative process to ensure that all critical climate change issues, including unique socio-economic and ecological profiles, would be adequately considered from the experiences of these districts.

As far as this research is concerned, the government is not required, and neither has it published progress reports on the implementation of the strategies and achievements to date. In 2018, ICAD was commissioned to apply the UNDP-sponsored Initiative for Climate Action and Transparency (ICAT) Sustainable Development Guide to measure progress towards the ambitions and targets of the NCCMP, measured against the SDGs. The research report is not published but is available either from ICAD or ICAT and has been provided to the government. The findings were largely positive in support of the policy development process and the implementation effectiveness of the NCCMP. It is important to keep in mind the IPCC report to the Regional Workshop held in Ghana, at which it foreshadowed the full impact of urbanisation on poverty, health and food security. These are not measures that are sufficiently addressed in the NCCMP and its strategies, and urbanisation is occurring at a pace that will challenge the capacity to manage the government and communities.

The nexus between climate change and extractive industries in Malawi

Unlike South Africa, and possibly other nations in the region where the extractive industries are a major and established contributor to the economy and employment with well-established regulatory regimes, the industry in Malawi is emerging. With the exception of speciality mining, such as gemstones and some minerals, mining has been for domestic requirements, which have been supplemented by imports to meet demand.

The past decade has seen the sector begin to realise the economic potential of domestic and international markets. The government's initiatives to bring its regulatory framework into line with global standards will, over the long term, deliver economic, social benefits and contribute positively to the government's development priorities. However, in 2020 the sector remains a modest contributor to the economy and employment.

During the middle of the past decade, when the industry peaked, and ahead of its rapid decline, employment remained relatively stable, with the new mining ventures relying on technology and modern mining techniques that are not labour intensive. Throughout, the largest employing sectors were the traditional and long-established quarrying and artisanal and small-scale mining. When the broader sector revives, employment will still not benefit until the sector delivers products for end-use, rather than offshore processing. With respect to climate change and GHG emissions, the extractive industries are modest contributors, as demonstrated in Table 1.3.

Table 1.3. GHG inventory/calculators. (***Source:*** *Environmental Affairs Department: http://www.ead.gov.mw/green-house- gas-inventory/calculators)*

Fossil Fuel Emissions										
Fuel	**Unit**	**Gas**	2010	2011	2012	2013	2014	2015	2016	2017
Petrol	Gg	CO2	231.5	239.8	227.8	249.1	249.1	304.5	380.2	383.1
Diesel	Gg	CO2	498.7	508	548.7	568.1	427.3	444.9	497.9	510.3
Paraffin	Gg	CO2	27	26.1	16.7	4.4	3.9	1.3	2.2	1.8

Fossil Fuel Emissions

Liquified Petroleum Gas	Gg	CO2	0.5	1.8	1.7	1.8	1.7	1.4	2.5	2.6
Jet A-1 fuel	Gg	CO2	29.8	32.7	19.2	25.2	19.8	22.3	22.5	0
Coal	Gg	CO2	164.5	158	156.8	159.5	134.4	159.2	126.4	131.2
Aviation Gas	Gg	CO2	0.7	0.3	0.6	0.5	0.3	0.4	0.4	0
Total			952.8	966.6	971.4	1,008.60	836.5	934	1,032.00	1,029.10

Emissions from industrial processes combustion (tCO2e)

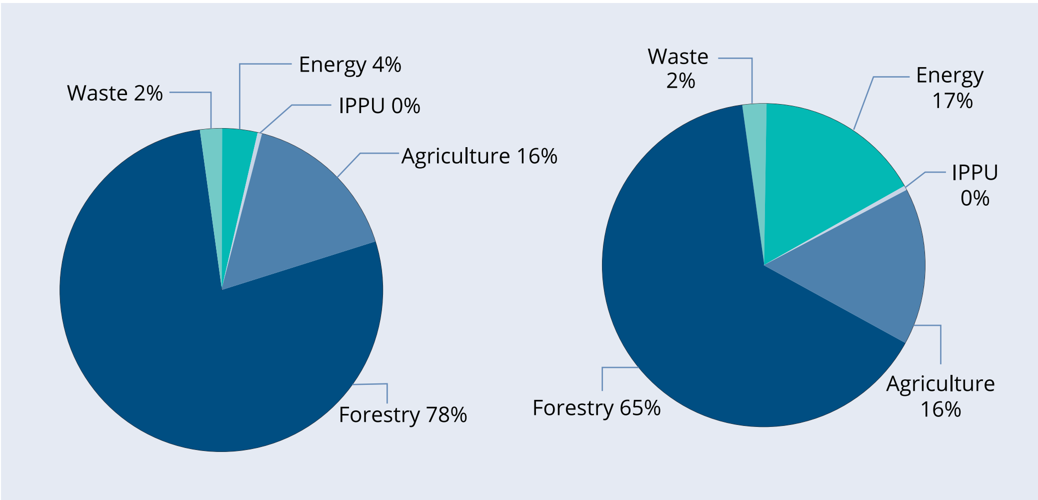
Type of Activity	**IPCC_ category**	**row gas**	**row unit**	2010	2011	2012	2013	2014	2015	2016	2017
Cement	2A1	CO2	t	-67,055	-61,962	-48,625	-55,468	-67,032	-71,328	29,927	25,007
Lime	2A2	CO2	t	23,938	0	16,859	16,016	15,215	24,968	28,823	31,626
Ceramic	2A4a	CO2	t	0	0	0	0	0	0	0	0
Total				-43,117	-61,962	-31,766	-39,452	-51,817	-46,360	58,750	56,633

Residential fuelwood emissions from biomass energy use - Reported under AFOLU, forest remaining forests (tCO2e)

Type of Activity	IPCC_ category	row gas	row unit	2010	2011	2012	2013	2014	2015	2016	2017
CO2 wood	3B1a	CO2	t	1,568,547	1,723,661	1,882,071	2,044,221	2,209,798	2,379,009	2,551,709	2,741,795
CO2 charcoal	3B1a	CO2	t	310,533	401,230	507,527	629,822	750,420	886,033	1,037,898	1,100,314
CH4 wood	1A	CH4	t	8,151	8,310	8,465	8,619	8,785	8,952	9,118	9,371
CH4 charcoal	1A	CH4	t	2,590	3,143	3,730	4,349	4,783	5,241	5,724	5,869
N2O wood	1A	N2O	t	601	612	622	632	642	652	662	675
N2O charcoal	1A	N2O	t	39	46	53	60	66	73	80	80

NOTES: Data available on the original document under these tabs: energy input, IPPU input, and fuel input

These tables provide a quantitative measure of the nexus between climate change and the extractive industries. The pie charts are extracted from the Government of Malawi's Nationally Determined Contribution submitted to the UNFCCC in 2015 and its projections to 2040. The government's measure of industrial processes and product use (IPPU), which is cement, lime and ceramic production, is minimal, while coal was only 12.7 percent of total energy emissions in 2015. Coal's contribution in 2015 was 0.5 percent of the total and in 2040 will be 2 percent of total emissions.



Sectoral emission in 2015 Sectoral emission in 2040

***Fig 1.3**.* Sectoral emissions data in 2015 (A) and projections for 2040 (B). *(**Source:** Malawi Nationally Determined Contribution 201)).*

Conclusion

For the future, the government and private-sector investors in the extractive industries sector have in place environmental assessment requirements and pre-project approval and monitoring. These are consistent with the government's environmental performance and climate change policies.

The nexus between extractive industries and climate change policies in Malawi is at best not material and in practice does not exist. The government has developed a comprehensive and appropriate climate change management policy, with a readiness to adapt. As the industries emerge, the governance arrangements are already in place to ensure the industry as a whole is climate-change compliant.

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2

The Mitigation and Adaptation of Climate Change through the REDD+ Programme: The Case of Zambia

Brian Chirambo and Felesia Phiri

Abstract

This study examines the potential of mining companies to implement or support the REDD+ programme as a mitigation and adaptation programme in Zambia. It provides an extensive look at the contribution of mining to environmental degradation and makes a case for why the sector needs to be more responsive to a climate change programme like REDD+, which has multiple benefits, first, for the company and, second, for the implementing communities and the world.

Introduction

Climate change is one of the greatest challenges facing the international community (FAO 2016; IPCC 2018). Reducing greenhouse gas (GHG) emissions and promoting greener, climate-resilient development is indispensable in attaining sustainable development. Small states and SSA countries are highly vulnerable to the physical impact of climate change (Adger et al., 2003); most of them have the least capacity to manage the risks and to adapt to the environmental, economic and social fallouts they are already experiencing.

Developing countries are today said to be contributing about 13 to 20 percent to global GHGs through deforestation and forest degradation. A mechanism called Reducing Emissions from Deforestation and Forest Degradation (REDD+) was consequently developed in 2008 to assist the countries address this growing concern. The REDD+ is an incentive market-based instrument that seeks to compensate those developing countries that take measures to curb deforestation and forest degradation over a long period. The mechanism therefore covers both the mitigation and adaptation components of climate change, by increasing the carbon stock while supporting community livelihoods. While the mechanism has existed since 2008, its implementation by many African countries, like Zambia, has been slow mainly because of the technicalities and financial costs that come with its set-up.

The extractive industries in developing countries like Zambia are also greatly contributing to climate change through high energy intake and emissions of GHG from their transportation and processing plants. In the case of Zambia, for example, it has emerged that, despite their higher carbon footprints, most mining companies are doing little to nothing in combatting or supporting climate change programmes. The link between programmes like REDD+ and the extractive industry therefore lies in its contribution to climate change and also the utilisation of large pieces of land.

It should be noted that land resources are Africa's most valued asset, which faces competing development needs for agricultural expansion, urbanisation and resource extraction. For countries in Africa, mining has the potential to contribute significantly to economic growth and to help lift millions of people out of poverty. However, there have been concerns that the benefits of the resource boom are not widely shared and do not always translate into local development and the conservation of natural resources. Large-scale mining investments have not always led to the generation of local employment opportunities, nor have they contributed significantly to poverty alleviation and the sustainable management of the natural environment.

The mining companies have, to a large extent, left significant negative environmental impacts that are felt both during mine operations and long after they have closed (Limpitlaw 2014). This study therefore examines the potential for mining companies to implement or support the implementation of the REDD+ programme as a mitigation and adaptation programme in Zambia. The study employed a qualitative approach to provide an extensive look at the contribution of mining to environmental degradation and makes a case for why the sector needs to be more responsive to climate change programmes like REDD+ during mining life and after mine closure.

Mining and climate change

The mining sector plays a crucial role in the economic development models and plans of many countries. However, limited knowledge exists that would help draw out the connection between climate change and natural resource development within the context of developing countries, which are projected to experience greater vulnerability to climatic shifts (Odell et al., 2018; Ruttinger & Sharma 2016). On the one hand, climate change carries the risk of further aggravating changes in natural environmental conditions. This may, in turn, disrupt resource-dependent livelihood generation, including herding, agriculture and fisheries. On the other hand, limited technical and financial resources already pose a challenge for current efforts to adapt to a changing climate. It should be noted, therefore, that the link between mining and climate change can not only provide an entry point for a larger debate on environmental and social standards in mining, but is also a way to engage with the climate change mitigation and adaptation agenda.

A number of studies have looked at how the extractive sector interacts with climate change. Odell et al. (2018) posit that the extractive industry, by its very nature, has a massive ecological footprint. The sector impacts climate change and is also impacted by it. Ruttinger and Sharma (2016), in their report titled, "Climate Change and Mining", posit that the mining sector was extremely energy-intensive and one of the major emitters of GHGs. Their study notes that the total CO_2 emissions vary across the industry, largely depending upon the type of resource mined as well as the design and nature of the mining process.

A study done in Zambia looked at the impact of mining on the forestry sector. It revealed that the sector, both through the clearing of new lands for project development and the extraction of wood energy for smelting, was contributing significantly to deforestation and forest degradation (Mwitwa et al., 2012) and consequently to climate change. The sector is also vulnerable to climate change. Changing climatic conditions will have both direct and indirect impacts on the costs of carrying out mining activities. This is predominantly a result of rising prices of energy, as well as climate change-related taxation (Odell et al., 2018; Ruttinger & Sharma, 2016).

Ruttinger and Sharma (2016) further point to the fact that some of the world's largest mining operations are currently to be found in remote, climate-sensitive regions. In effect, their impact on the environment brought about reputational risks to the companies and their social licence to operate. This, they say, may be fatally permanent, if nothing is done to remedy the situation. Further, these risks and the absence of a concerted industry-wide approach to the adaptation to climate change may threaten investor confidence and impact insurance dynamics over the long term (Ruttinger & Sharma, 2016). It is important therefore, that the role of the mining sector in a broader development context, including its complex interlinkages with climate change, is better understood in order to come up with ways in which the sector can significantly contribute to mitigation and adaptation efforts of climate change, as well as enhancing sustainable development.

The REDD+ mechanism

Reducing Emissions from Deforestation and forest Degradation (REDD) refers to forest-and land-based activities that abate forest carbon emissions by minimising or preventing forest conversion and destruction (Appiah & Gbeddy, 2018). The REDD programme was established based on the evidence that a large percentage of current annual carbon emissions resulted from the loss of tropical forest (Madeira, 2008, as cited in Appiah & Gbeddy, 2018). Deforestation and forest degradation, mainly from tropical developing countries are said to be contributing about 17 to 20 percent of the global GHG emissions (Bluffstone et al., 2013; Norman et al., 2013; Parker et al., 2009). In response, a programme aimed at reducing emissions from deforestation (REDD) was suggested in 2007 (Allen & Clouth, 2012; Flaming & Stanley, 2010; Parker et al., 2009; Pistorious et al., 2010; Willem et al., 2013). Unlike REDD, REDD+ goes beyond deforestation and forest degradation to encompass additional functions of ensuring that there is sustainable forest management, including the enhancement of forest carbon stocks (Appiah & Gbeddy, 2018).

From its establishment, REDD has evolved from focusing on addressing deforestation to include dealing with drivers of forest degradation, enhancing sustainable development and promoting conservation (REDD+). A series of decisions have been made at various international conferences of parties (CoPs) of the UNFCCC, providing methodological guidelines and conditions for an internationally accepted REDD+ programme (Turnhout et al., 2016; UNFCCC, 2014). Among the key decisions that REDD+ has made is the roles of actors in making the mechanism work; for example, developed countries have been given the responsibility of providing financial and technical assistance to developing countries that are a party to the programme to assist them to prepare for the out-scaling of the programme. Developing countries, on their part are the implementers and are expected to localise REDD+ in line with internationally negotiated guidelines and standards.

As in 2021, REDD+ is part of the Paris Agreement, which was agreed to at the 2015 UNFCCC conference of parties held in Paris, France (Rakatama et al., 2016; UNFCCC, 2015). The REDD+ mechanism is therefore promoted on the claim that reducing emissions from avoided deforestation and forest degradation in tropical developing countries was the most cost-effective way available for mitigating climate change (Angelsen et al., 2012), compared to addressing energy- and transport-related emissions.

REDD+ mechanism is anchored on the concept that providing incentives to developing countries to reward good forest management practices will motivate them to fight deforestation and forest degradation and subsequently reduce GHG emissions. It is hoped that the incentive will increase the value of standing trees compared to felled trees. It is also expected that poor forest communities who depend on trees for their daily living will benefit financially and shift to other forms of livelihood and support conservation and the protection of forests (Strassburg et al., 2009).

However, the REDD+ mechanism faces several obstacles to its success (Angelsen et al., 2013; Angelsen et al., 2012). These include inadequacy and uncertainties in financial flows, complexity in identifying real drivers of deforestation and forest degradation, a lack of capacity in implementing countries, problems of handling emission leakage, making sure that safeguards are in place to protect the rights of indigenous people, developing of equitable benefit-sharing frameworks, a lack of political will to push for necessary policy reforms, and lack of technology and equipment in most participating countries (Accra Caucus, 2013; Angelsen et al., 2012; Atela, 2013; Aurenhammer, 2015; Caravani et al., 2013; Herold et al., 2014; Kalaba, 2016).

The sustainable quality and success of REDD+ initiatives are highly dependent on the participation of local communities, especially smallholder farmers who live in forest fringe areas (Appiah & Gbeddy, 2018). The question that this research is therefore asking is: what opportunities and challenges are there for mining companies to implement or support the implementation of REDD+ as a climate change mitigation and adaptation programme?

The REDD+ framework in Zambia

In responding to the globally negotiated ideas on REDD+, a need was identified in 2008 to pilot the programme and draw lessons. These lessons would inform further negotiations as well as the out-scaling of the policy (UN-REDD, 2015a; Policy and Meeting 2015). Two international programmes were created. First was the United Nations collaborative programme called UN-REDD+ and, second, the World Bank-led, Forest Carbon Partnership Facility (FCPF) (Parker et al., 2009; Thompson, Baruah, & Carr 2011; UN-REDD, 2010 2015b; Watson et al., 2013). The objective of these two programmes was to help tropical developing countries get ready to participate in the global REDD+ mechanism (Parker et al., 2009) on reducing emissions from forests.

A three-phased approach was designed as a global process for countries implementing REDD+. Phase one was the development of the national REDD+ strategy in readiness for global participation; phase two was the trial stage in which the country began to implement its strategy or action plan; and, phase three was the national out-scaling stage that involved participating in international carbon trading by the implementing country (UN-REDD, 2010). The preparation phase was designed to prepare the countries to participate in the global carbon market through the trade of stored forest carbon. It is further expected that, during this phase, participating countries will link REDD+ with existing national forest-management policies and sustainable development programmes. The process, therefore, demands national policy and institutional reforms, the development of a national monitoring review and verification (MRV) mechanism, developing sharing mechanisms for carbon credits, and implementing safeguards to ensure that the rights of indigenous people and local communities are protected (AIPP, 2014; Cadman et al., 2016; Chhatre et al., 2012; UNFCCC, 2014). In effect, developing countries participating in REDD+ were expected to produce national REDD+ strategies that covered all these areas and detailing how REDD+ would be governed and implemented in their countries.

Various local and international actors play different roles in the process of developing national REDD+ strategies. For UN-REDD+, three UN bodies - Food and Agriculture Organization (FAO), United Nations Environment Programme (UNEP) and United Nations Development Programme (UNDP) – collaborate to provide technical and financial support to national actors in the development of national REDD+ strategies. Other international actors include bilateral and multilateral agencies.

They also provide financial and technical support as well as financing the research needed to inform the strategy process and content. Local actors include government departments, local civil society organisations, local community representatives, the private sector, academia and consultants. All these actors are brought together to participate in the process of designing national REDD+ strategies as important stakeholders.

Owing to its higher rates of deforestation and forest degradation, Zambia was selected among the first nine countries to pilot REDD+ in 2009 under the support of UN-REDD+ (Fumpa-Makano, 2011). The country had finished its first phase by 2021 and had developed its REDD+ national strategy in readiness for trial activities (Attafuah, Kasaro, & Fox, 2014; Sweden, 2014; FCPF, 2015) and therefore experienced significant progress in REDD+ processes.

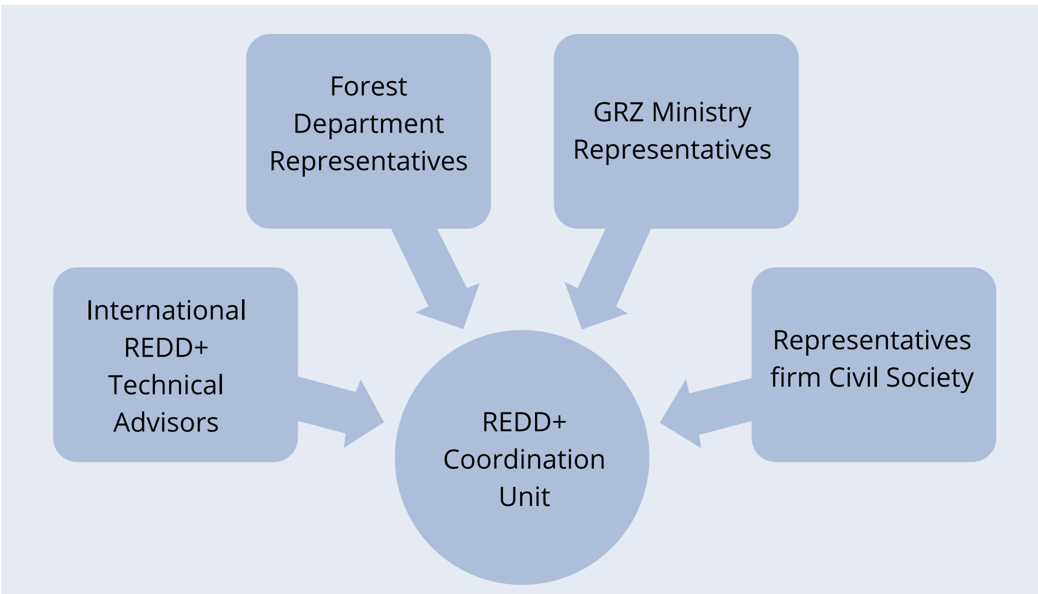

Fig 2.1*.* The structure of the various actors in the developing national REDD+ strategies in Zambia. *(**Source:** Created by Brian Chirambo and Ms Felesia Phiri.)*

Zambia initiated its REDD+ process as part of phase 1 in 2008, culminating in the approval of the National UN-REDD Joint Program from 2010 to 2014. The country accomplished the following in the readiness phase: the drafting of the initial version of Zambia's Safeguard Information System (2012); development of the National REDD+ Strategy, which was approved in 2015; development and submission to the

United Nations Framework Convention on Climate Change (UNFCCC) of its Intended Nationally Determined Contribution in 2015; development of a national forest monitoring system for relaying and sharing information in 2016; and, submission of the forest reference emission level (FREL) to the UNFCCC in 2016.

In transitioning from phase 1 to phase 2, Zambia developed its REDD+ Investment Plan (2017). The Plan identified three core investment priorities (CIPs), eight components and 59 key activities (KAs) for investment. These served as the basis for a risk-benefit analysis (RBA) in the safeguard development process, the results of which would be used to revise the co-benefits section and results framework of the investment plan. Phase 3, which was scheduled for 2020-2030, was centred on results-based payment. Like Tanzania and the Democratic Republic of Congo (DRC), which have gone on to develop their national strategies focusing on forest governance, Zambia's strategy also placed emphasis on strengthening forest governance and the inclusion of local people in the conservation with benefit-sharing coming from such interventions (Duguma et al., 2014; Rantala & Di Gregorio, 2014; Newton et al., 2015a).

Like many other developing countries, however, Zambia has complex social, economic and political problems that are driving forest-cover loss. Some of these include poverty, low access to clean and reliable energy and generally poor governance of forests (Kalaba, 2016; Tembo, Mulenga, & Sitko, 2015; Vinya et al., 2011). On energy, for example, over 90 percent of the country's rural communities were still using wood energy for cooking and heating (Buckley, 2010). In addition, the country had been experiencing a seriously erratic supply of clean energy in cities and towns, largely due to an increased demand for hydroelectric energy, driven by increases in the extractive industries (Haselip, Desgain, & Mackenzie, 2015; Shane et al., 2016). The repercussion of this situation was that most Zambian communities, whether poor or rich, had turned to charcoal and wood fuel as a direct energy substitute to meet their cooking and heating demands (Kalaba 2016; Tembo, Mulenga, & Sitko 2015; Vinya et al., 2011).

The other key driver of deforestation and forest degradation in Zambia was agriculture (Kalaba 2016; Tembo, Mulenga, & Sitko 2015; Vinya et al., 2011). Zambia Vision 2030 places the emphasis on diversifying the economy from dependency on copper to agriculture, a move that further puts pressure on forest land. The agriculture sector has for a long time been driven by a politically designed incentive structure that provides farming inputs in form of seed and fertiliser to subsistence farmers with a push for increased crop production. Nevertheless, various studies have implicated subsistence or traditional forms of agriculture as being a major contributor to agriculture-driven deforestation in the country. The REDD+ mechanism is therefore seen as a viable alternative land-use programme that would enhance livelihoods that are less destructive to forests. It is on this basis that Zambia adopted a landscape approach in which REDD+ projects would be expected to support existing activities by making them more profitable and climate-smart. This paper set out to look at how the extractive industry could take on REDD+ as a critical climate change programme in its mining cycle and beyond.

Nexus of the REDD+ and the mining industry

In light of significant environmental and socio-economic impacts of mining, as well as its contribution to climate change, there is an urgent need for the sector to get more involved in climate change mitigation and adaptation programmes. This study identified UN-REDD+ initiative as a mechanism that the extractive industry could utilise and hence contribute positively to combating climate change. Mining companies could consider REDD+ as an alternative land use after mine closure or could support communities with technical expertise or financial resources for implementing this programme.

Implementing REDD+ in SSA has unique features; Africa faces a high potential for increased emissions, as African forests are under continuous threat of deforestation and degradation (Gizachew et al., 2017), and Africa is home to the largest proportion of forest-dependent subsistence households in the world. Consequently, the drivers of deforestation and forest degradation in the continent are mainly related to subsistence-livelihoods and economic-development (Gizachew, et al., 2017). The challenge to the African forest sector is how to reduce the fast rate of forest depletion, and at the same time manage forests and woodlands to provide sustainable livelihoods to the large and rapidly growing forest-dependent populations.

Apparently, land-use planning (LUP) provides a basis for improved management and use of resources and, where implemented, can assist in appropriate use of land types. The participation of local municipalities in LUP is of particular importance, since they are the channels for the provision of land ownership certificates and are consequently key for facilitating appropriate resource use and land tenure systems. Therefore, REDD+, which by design is a highly participatory programme, emerges as a viable alternative to those activities, such as mining, which lead to deforestation and forest degradation.

The REDD+ mechanism has the potential to not only represent Africa's contribution to the global initiatives to curb emissions, but also to improve the environmental-performance outlook of the extractive sector, if they choose to take it on. The REDD+ mechanism promises socio-economic development, including poverty reduction and sustainable livelihoods (Appiah & Gbeddy 2018; Gizachew et al., 2017). The envisaged contribution to the goal of socio-economic development is, particularly, more attractive than the climate goal because, in the African context, socio-economic development takes precedence over climate change mitigation. This scenario provides an opportunity for the extractive industries to invest in the REDD+ mechanisms in rural communities that desperately need improvements in their livelihoods.

Other challenges facing the REDD+ implementation are those of forest governance and related land-tenure reform issues (Gizachew, et al., 2017), but highly sensitive in the context of Africa. Mining companies already have large tracts of land under their concessions, which can be used for their REDD+ projects both during their mining operations and after mine closure, as a way to rehabilitate the land and contribute to the efforts of reducing GHG emissions. Mine companies also have good relations with traditional leaders who are custodians of traditional lands where REDD+ projects can be extended. Further, REDD+ requires a credible system that will ensure the measurement and MRV of emissions from forests (Gizachew et al., 2017). African countries, however, have not been able to accurately measure and report the carbon in their forests, but, with the help and support of mining companies, the MRV of emissions from forests can be achieved because most of these companies have both the technical equipment as well as the skilled human resources, which can implement such a programme.

The private sector, like that of extractive industries, can contribute to REDD+ in three key areas, namely innovation, investment and implementation. With regard to *innovation*, one of the key attributes of the private sector is the development and deployment of new technologies and innovations. Extractive enterprises like mining companies must respond to market pressures and need to stay competitive in an evolving environmental, legal, regulatory and fiscal landscape. They can do this by incorporating new systems, knowledge, technologies and practices into their operations to boost efficiency, productivity and profits. These skills and capabilities are needed to decouple growth from resource consumption and environmental degradation.

As for *investment*, the transition to a green economy requires structural changes to current and future investment patterns. The UNEP Green Economy report suggested that an average annual additional investment of USD 40 billion would be required to halve global deforestation by 2030 and to increase reforestation and afforestation by 140 percent by 2050, relative to business as usual. Given the current strained state of public finances globally, in the wake of several financial crises, private capital is essential to meeting this requirement.

Innovation and investment require various forms of *implementation* to bring about results on the ground. Ultimately, as the largest terrestrial land users, the private sector needs to be heavily involved in activities that are required to transition to a green economy. It is therefore from this background that this study has sought to clearly identify the possibilities and challenges of having an extractive industry, particularly mining, taking up the REDD+ programme as a climate change mitigation and adaptation programme.

Participation of mining companies in climate change programmes in Zambia

The findings of this study have shown that the mining companies in Zambia were doing very little in addressing climate change and its impacts. Of the 11 mining companies that were surveyed on the Copperbelt and north-western provinces of Zambia, eight did not have any independent climate change programme deliberately designed and implemented by the respective company. The remaining three that had climate change activities only did these in the form of providing support to NGOs or supporting environmental-sensitisation events that covered climate change as a topic. These efforts, as observed from their annual environmental performance audits, were mainly in the form of climate-sensitisation programmes, school debates and a few climate-smart agriculture projects (Chibuluma Mines, 2018; Konkola Copper Mine, 2019; LCM, 2018).

The study revealed that much of the environmental attention in the mining sector was given to issues that were covered in their mining and environmental licences for purposes of fulfilling legal obligations that ensured they continue with their mining operations. Climate change programmes are seen by many mining companies in Zambia as a corporate social responsibility issue that the company could decide to do or implement only when resources permit. One representative view from a respondent is given below:

> *Inspectors only come to look at our performance in line with emissions or discharges as per licences. There is nothing about climate change programmes. This is also found in our environmental management plans, which only focus on mitigation around our area of operation.*

The findings also revealed that finance for environmental management projects in most mining companies in Zambia was very low. This is because most mining companies viewed environmental expenditure as a cost that was affecting company profits. This view had affected any prospects of investing in climate change programmes like REDD+.

There is a general agreement by environmental practitioners from the mining sector that most mining companies have a very low interest in investing in climate change programmes because they are complicated and very involving. However, the study found that there was interest in supporting other groups to implement these programmes as opposed to directly developing and implementing climate change programmes like REDD+. The study also found that, although most top management individuals were aware of climate change programmes, their focus was on production and meeting company targets.

REDD+ opportunities and challenges for mining companies in Zambia

The face-to-face interviews conducted with 11 environmental personnel from six mining companies brought out some useful insights into the opportunities that mining companies have in implementing climate change programmes like REDD+. It emerged that climate change programmes around adaptation and mitigation had practical programmes that resonated well with the local communities within the mining communities. One respondent pointed out smart agriculture and diversification into the harvesting of non-timber forest products as very significant climate change programmes that had greatly improved livelihoods in communities around the mine. These interventions not only reduced social pressure on the mining companies, but they were also seen as legitimising interventions for the mines' social licence to operate. The very nature of these activities also positively impacted the local and international outlook of the company as a responsible corporate citizen.

The study also found that most mining companies owned large pieces of land that often were not utilised but were merely protected from human exploitation without realising any tangible value. The mine companies were paying the cost of ensuring that people did not encroach on these pieces of land and therefore any interventions that would generate value for such areas were a great opportunity for them. This is what one respondent said:

> *We own large pieces of land under the mining licence. It's a huge cost to protect these lands from encroachers but we have to do it because that is what the law requires of us. You must also know that these areas are dangerous, especially where we are doing underground mining and blasting.*

The study also found that most mining companies in Zambia have very good relations with traditional leaders who own and control huge pieces of customary land. This is because most old and emerging mining companies are located in rural and undisturbed forest areas of the country, which are largely under the control of traditional leadership. The rural communities are largely dependent on agriculture and the forests for their livelihood. The REDD+ programme therefore presents a great opportunity to enhance livelihoods for most of these communities. The long-standing relationships that these mines have with communities and the traditional leadership make it easy for mining companies to gain consent and implement climate change programmes like REDD+ that require huge pieces of land and community participation and approval.

The other great opportunity that emerged was the financial capacity and access to finance that mining companies had to facilitate the implementation of climate change programmes like REDD+. Further to this was the huge resource advantage in terms of technology, skilled human resources and other material resources required in the successful designing and development of REDD+ programmes that the mines posed.

In terms of the challenges in implementing REDD+ and any other climate change-related programmes, the study found that mining companies had very little participation in national climate change programmes, which were largely driven by government departments and NGOs. There was very little information on how the private sector and, particularly mining companies in Zambia, could successfully participate or support large climate change programmes like REDD+. As one respondent commented:

> *We hardly get invited to programmes on climate change. Sometimes we only participate in initial meetings but we never get to be called to subsequent follow up and so we never know how these projects progress or end up.*

In order for the private sector's potential to be unlocked, the current paradigm needs to change and major structural issues need to be addressed. Market signals that can be influenced by subsidies, taxation, pricing, regulation and land tenure issues often contribute to making deforestation a profitable activity. Ensuring that this new paradigm is efficient, effective and equitable requires thorough coordination and collaboration between the public sector, private sector and civil society.

Another main challenge that this study found was the weakness of regulatory institutions. The institutions charged with the responsibility of regulating mining companies focused on inspection and assessment of compliance levels against licences and operational conditions given to the mines. There was little, if any, in the form of deliberate efforts by the regulatory authorities to compel or motivate mining companies to implement or support climate change programmes such as REDD+. This therefore made most mining companies focus their energies and resources on addressing pollution at a company level, without extending their investment in climate change adaptation and mitigation programmes.

The study also noted another challenge that had to do with the estimated cost and the time involved in setting up the REDD+ programme before the actual carbon credits could begin to flow into the project. The study however found that the amounts involved would be within the reach of most mining companies, which controlled investments ranging in millions of dollars. What was needed the most for REDD+ was the securing of land, which had to be done based on free consent (Pagiola and Bosquet, 2009).

Willingness of mine companies in Zambia to implement or support REDD+

The question of whether the mining companies would be willing to implement or support the implementation of REDD+ through a different agent was important to establish the initial interest for these entities to participate in climate change programmes. The study found that all companies interviewed were interested in participating in a programme like REDD+ but were all not very sure whether to implement it themselves or to work with another entity. All 11 respondents said they could only know how they would participate if they had the full information of what was involved and the amounts required for such a programme. The study further revealed that, although climate change programmes were discussed in company meetings, the focus was never on long-term programmes like REDD+, which required the full dedication of the company. One respondent said the following:

> *You need to understand, mining is very involving and capital intensive. We focus on production and meeting targets given to us by our investors. If we have to engage in another involving programme, then there must be serious and strong justification.*

Conclusion

This study has clearly shown that REDD+ presents a great opportunity for mining companies in Zambia to actively participate in climate change adaptation and mitigation programmes beyond what they have done in the past. The companies are well equipped in terms of skilled labour and have the financial capacity to finance and support the setting up and implementation of REDD+ programmes in the communities within which they operate. Because of their long relations with communities and traditional leaders, they have an added advantage in securing consent for large pieces of land, which is a critical requirement for setting up REDD+ projects.

The REDD+ programme further presents the mining companies with multiple potential benefits, which include the sustaining of social licences to conduct their mining activities, the reduction of their carbon footprint and financial benefits from the trade of carbon. The REDD+ programme also presents the opportunity of turning into an alternative source of livelihood for mine workers in case of a mine closure.

The challenge, however, is that mining companies in Zambia have little information on climate change programmes like REDD+ and have thus not actively participated in them.

There is strong reason to conclude that the lack of information flow and follow-up on climate change is because the government agencies responsible for climate change programmes have not taken deliberate steps to engage or compel the extractive sector to participate in the development process of such programmes. On their part, the extractive industries themselves have not taken serious internal initiatives to implement climate change programmes. They look at the programmes as costly and not worth investing in. They have focused more on the environmental compliance of their operations as stipulated in their mining and environmental licences. Anything outside these licences is seen as a cost that can only be covered if resources permit. There is a need to bridge this information gap in order to motivate or compel the extractive industries to begin to actively participate in climate change programmes. There is further need for the government and other agencies to enhance and follow up on the full participation of the mining companies in the design and implementation of climate change programmes.

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3

Climate Change and Coal Mining in Southern Africa: Evaluating the Political Economy, Laws and Prospects for a Just Transition in Zimbabwe and SADC

Lenin Tinashe Chisaira

Abstract

The coal mining industry is the mainstay of some of the major economies in the SADC region, just as it has been the anchor of development in the Global North. The doctrine of the shift to renewable energy worldwide has given rise to fears that such a transition will pose economic hardships on the economies as well as give rise to unemployment in as far as the coal and fossil workforce is concerned. The research makes a critical assessment of the prospects and feasibility of a just transition that does not harm the environment, infringe human rights and social cohesion as well as safeguard the transformation of current fossil and coal workers, in terms of timing, legal instruments, budgeting and policy formulation. It makes a timeous call for climate financing for a just transition, building labour justice in the extractives sector, and the inclusion of mine workers and less-developed communities in energy and environmental policy.

Introduction

Southern Africa, like most of Africa and the rest of the Global South, suffers immensely from the impact of climate change (SADC, 2010). Scientists have attributed global warming and climate change to the prevalence of human-activity-induced GHGs in the atmosphere, of which the most common is carbon dioxide derived from fossil fuels, particularly the coal mining industry. This industry is the mainstay of some of the major economies in the SADC region, just as it has been the anchor of development in the Global North (consisting of countries such as the United Kingdom, Germany, United States of America and Australia).

In terms of regional and continental development goals, the African Union (AU) Agenda 2063 outlines that:

> *Whilst Africa at present contributes less than 5% of global carbon emissions, it bears the brunt of the impact of climate change. Africa shall address the global challenge of climate change by prioritizing adaptation in all our actions, drawing upon skills of diverse disciplines with adequate support to ensure implementation of actions for the survival of the most vulnerable populations, including island states, and for sustainable development and shared prosperity (African Union Commission, 2015).*

The calls to address climate change cautiously, while shifting from coal and fossil-based industries, makes common sense. The courts in Southern Africa have also begun making strides towards climate justice and its link with administrative justice.

Still, in the Global South and Southern Africa, there are fears that such a transition will pose economic hardships on economies as well as lead to the unemployment of coal and fossil workers. It is therefore imperative that social, environmental and economic justice researchers and practitioners come up with critical positions on the prospects and feasibility of a just transition that does not harm the environment, human rights and social cohesion, as well as safeguard the transformation of current fossil and coal workers, in terms of timing, legal instruments, budgeting and policy formulation.

The political economy of coal extractivism in Southern Africa

The extractive industry is the mainstay of most Southern African economies, from the diamonds in the Democratic Republic of Congo (DRC) and Zimbabwe to gold and coal in South Africa and Zimbabwe. The importance of coal in Southern African economies is aptly highlighted by its significance in the major SADC state of South Africa, where the coal industry "employed 92,230 people in 2019 and 86,647 in 2018), representing about 19 percent of total employment in the mining sector". Furthermore, coal is the main source of energy and, as an industry, provides jobs for many members in Southern Africa, especially South Africa and Zimbabwe (see figure 3.1).

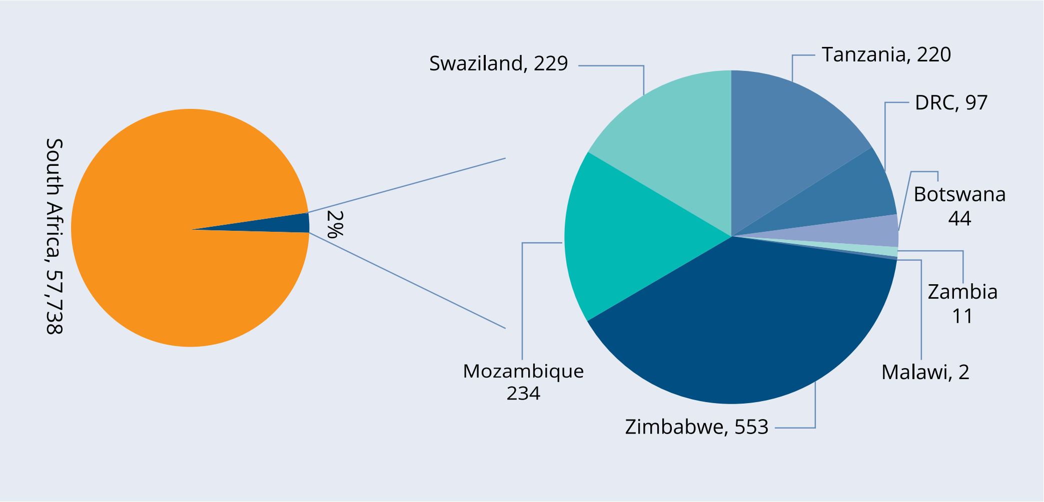

Fig 3.1. Southern African recoverable coal reserves, 2003 (Million Short Tons*). (**Source**: From Annual Energy Review 2007 (EIA, 2008)).*

The political economy of the coal and fossil industry has been characterised by an impunity-oriented relationship between corporates, power utilities and governments, with continuous coal deals being brokered regardless of climate crises (IEA, 2019; 2020). These relationships have also manifested in other aspects of the extractive industry, especially in the diamond and platinum industries as was the case in the 2012 massacre of mineworkers at Lonmin Marikana Mine by elements of the South African Police Service (SAPS).

In the energy sector, the fossil industry captains are usually powerful enough to exert more influence on governance than the alternative and cleaner energy sectors. As Admark Moyo points out:

> *The alternative energy sector patently stands to benefit from the reduction of greenhouse gas (GHG emissions. However, at least until recently, the power of the alternative energy sector to influence public opinion and political outcomes has been dwarfed by the wealth and power that the fossil-fuel industry has put behind their fight for immediate economic prosperity and survival. (Moyo, 2019, p. 104)*

The power of the extractive sector to influence governments is not a new phenomenon. The power dynamics have been apparent during the colonial era and in the current neoliberal economic environment. However, these are also the industries that can better be served by a timely transformation from fossil use to alternative sources of energy.

The economies of Southern Africa, being led by natural-resource extraction, have not escaped the challenges of environmental pollution. The anti-pollution discourse gets strained when juxtaposed with the ever-pressing need to save dirty jobs and people's livelihoods. However, the pollution picture is dire, with the top culprits being coal and gold extraction that lead to the emissions of air and environmental pollutants such as carbon dioxide, methane and mercury. This pollution picture in the SADC region is also painted by researchers, such as Abioye Fayiga:

> *South Africa has been ranked the second-highest emitter of Hg in the world probably because it is the third-largest coal producer in the world and coal accounts for 64% of the country's primary energy supply. South Africa is also one of the largest producers of gold in the world, and Hg emissions from this source are greater than from coal combustion. Mercury is used mainly for the processing of gold, and analysis show that 70–80% of the Hg is lost to the atmosphere during processing, while 20–30% is lost to tailings, soils, stream sediments and water. Cumulatively, the amount of Hg released every year into the atmosphere is about 3–4 t in the whole Lake Victoria Goldfields of Tanzania and 3 t in Zimbabwe. (Fayiga et. al., I018, p. 49)*

Furthermore, the current challenges of a changing climate require Zimbabwean and Southern African states to adapt to, while also mitigating, climate change. These elements need the participation of local authorities as they wield the power to influence community-based policies. This is most relevant to urban communities, which utilise most of the energy from fossil fuels than do their rural counterparts. Roberts et al reiterate the adaptation need, with a focus on urban communities:

> *Given that urban economies, infrastructure and lives (particularly those of the most vulnerable) in the Global South are likely to experience higher and earlier risk and damage than those in the Global North, Southern cities require a dramatic break from the status quo. Because of their limited role in creating the climate change crisis, and their resource-scarce and risk-prone state, for many this will mean prioritizing adaptation. (Roberts et al, 2012, p. 170)*

The aspect, however, is more effective in states with devolved governments such as South Africa and Kenya. In Zimbabwe, Malawi and Zambia, for instance, policy change is mainly concentrated at the central government level and that is where the drive towards adaptation should be implemented.

Policy and legal frameworks on climate change and coal mining

The impact of the coal and fossil-fuel industries on climate change have influenced legal and policy developments at the national, regional and global levels. Globally, UNFCCC, protocols and attendant annual CoPs provide an overall structure for climate change-related aspirations and negotiations. CoP24 was instrumental in the relationship between coal mining and climate change when states came up with the Solidarity and Just Transition Silesia Declaration that deals with the transition of carbon workers in a time of the climate crisis. In the SADC region, monitoring of climate change happens under the auspices of the SADC Climate Services Centre. In 2011, the region also developed the SADC Climate Change Adaptation for the Water Sector, which is specific to the water sector.

It can be argued that, nationally, the legal framework in Zimbabwe is progressively poised for the eventual transition to cleaner energy in terms of environmental and labour rights protection. The challenge is in the implementation rather than in the existence of a viable legal and policy framework.

The legal factors governing the relationship between coal and climate change in Zimbabwe and Africa consist of environmental management laws, renewable energy policies, labour laws and the influence of international treaties towards addressing climate change, achieving just transitions and providing for community development. Legal issues on the relationship between coal, climate change and administrative justice featured in recent years in a case concerning coal mine development brought by Earthlife Africa Johannesburg against the Minister of Environmental Affairs and Others in South Africa (*Earthlife Africa vs Min. of Env. & Others, 2017*). In the case, the court ruled that the ministry, in allocating additional coal mines, has to take into consideration climate change impact assessment reports, palaeontological impact assessment reports and comments on these reports from interested and affected parties.

International law

The aspect of international law dealing with climate change is mainly shaped around UNFCCC, formulated in 1992. International treaties, such as the UNFCCC, are amended by protocols that include the Kyoto Protocol and the Paris Agreement. These protocols mainly deal with the need to attain clean development mechanisms as well as encourage states to come up with binding GHG emission reduction strategies. They are buttressed by additional agreements and declarations reached through negotiations at the annual CoPs. CoP meetings also deliberate on the annual reports from IPCC. The 26th Conference (CoP26) was supposed to be hosted by Glasgow, Scotland, in the United Kingdom, in late 2020, but it was postponed as a result of the Covid-19 pandemic.

International law mainly depends upon consensus among state representatives. As Ademola Jegede notes, "The negotiation and outcome of international climate change instruments are patterned around the conception of climate change as a global environmental challenge which is best addressed through consensus and co-operation" (Jegede, 2016, p. 33). This element of international negotiation is problematic, as it rarely manages to get tangible goals met. For instance, the Paris Agreement was reached in 2015, but, as of 2020, had not yet been implemented despite the parties agreeing on parts of the Paris Rulebook during CoP24 in Katowice, Poland (Carbon Brief, 2018). The Paris Agreement's main objective is strengthening of the global response to the climate change by keeping a global temperature rise this century well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C. The measures to attain such goals include supporting developing countries and investing in cleaner energy. In order to meet the long-term goals, the Paris Agreement and the attendant rule book provide for the need for states to come up with plans for Nationally Determined Contributions (NDC) every five years.

In terms of the coal industry, the main challenge stems from the fact that coal still rules the industry and the politics of many states, and socially in the Global South. Developing states have been reluctant to drop coal at an equal pace with developed states. The contentions range from the desire to catch up with developed states to the need to safeguard existing coal and fossil-fuel jobs. The other challenge has been the lack of funding for cleaner energy projects. Negotiations on funding mechanisms for developing states have proved to be an uphill task at the global climate talks, especially with the withdrawal of the United States from the Paris Agreement under the Donald Trump presidency (Lewis, 2020).

National framework

In most African states, domestic laws directly dealing with climate change or specific to the coal industry have not been greatly enacted. Kenya is one of the few states to have come up with a specific climate change act. In the SADC region, as in the rest of Africa, this has not been the norm. As Michael Addaney points out:

> *The impacts of climate change in Africa are likely to prompt adaptation responses that touch on many aspects of law and policy decision-making. While it is too early to predict which path is more apt, there just has not been enough climate change legislation at the domestic level on the continent. (Addaney, 2018, p. 4).*

As Africa continues to fight for adaptation, mitigation and the just transition from fossil industries, there will be a need for quicker steps towards climate-related laws and policies. Zimbabwe's domestic (municipal) law has been well-positioned to protect the rights of workers and communities in a changing world though it is not yet up to scratch on coal and climate change. The current national legal framework concerning Zimbabwe's coal, climate change and the just transition, consists of various pieces of legislation with the main ones being the Constitution of Zimbabwe, the Environmental Management Act and the Mines and Minerals Act.

Zimbabwe climate policy

Zimbabwe has developed a number of policies related to the climate crisis. Relevant policies include the National Climate Policy, National Climate Change Response Strategy, National Renewable Energy Policy and the Biofuels Policy of Zimbabwe. The Zimbabwe Climate Policy was formulated in 2016. Among a host of aspirations, some of the worthy principles of the policy include the need for the adoption of low-carbon development pathways that incorporate national developmental aspirations, vision and national programmes. The policy also calls for building resilience to climate challenges through adaptation programmes that should be pursued concurrently with climate change mitigation programmes. In terms of goals, the policy aims to reduce vulnerability to climate variability and climate-related disasters by strengthening adaptive capacity, education, awareness raising and technology transfer.

While the aspirations of national climate policy are noble, the policy can easily fall into the misfortune of other climate policies in the Global South. These policies are dependent on climate financing from developed and industrialised states, which bear the major responsibility for causing the climate crisis in the first place but are reluctant to pay. The opening remarks from then President Robert Mugabe affirms Zimbabwe's aspiration of reducing "by 33% below business as usual the energy emissions per capita by 2030" and that this is "based on the availability of financial resources and technology transfer from bilateral and multilateral funding mechanisms in addition to domestic financing" (Zimbabwe, 2016).

The Constitution of Zimbabwe and coal

The Zimbabwean constitution is one of the newest in the world and has some very progressive clauses on top of being the supreme law of the nation (Zimbabwe, 2013, sec 2 (1)). The Constitution of Zimbabwe buttresses all existing legislation and policies by providing for human and environmental rights that can be claimed by every person who is directly or indirectly affected by environmental decisions. The constitution, for the first time, provides for the right of every person to an environment that is not harmful to health and that takes into consideration ecologically sustainable development and the use of natural resources, while promoting economic and social development (Zimbabwe, 2013, sec 73). If utilised well, this would be the backbone of responsible green governance in Zimbabwe since natural resources would be used in a considerate manner that advances people's social and economic livelihoods.

The current nature of coal extraction and its threat to human health and the environment is potentially in violation of constitutional human and environmental rights. In the coal industry, health consideration should entail a quicker shift from coal and fossil energy to cleaner forms of energy and the transformation of fossil workers to cleaner jobs. The objectives of the 2013 constitution present immense possibilities for clear responsible investment.

The constitution states that Zimbabwe is founded on values and principles that includes the following: fundamental human rights and freedom; recognition of the inherent dignity and worth of each human being; recognition of the equality of all human beings; and, gender equality (Zimbabwe, 2013, sec 3). These values and principles are backed by progressive provisions in the National Objectives and the Declaration of Rights. The National Objectives are meant to "guide the State and all institutions and agencies of government at every level in formulating and implementing laws and policy decisions that will lead to the establishment, enhancement and promotion of a sustainable, just, free and democratic society in which people enjoy prosperous, happy and fulfilling lives" (Zimbabwe, 2013, sec 8).

The specific National Objectives that have a bearing on responsible green governance include the objectives of the fostering of fundamental rights and freedom, which in essence promotes the realisation of the rights outlined in the Declaration of Rights and which will be discussed later in the chapter. The objectives also include the attainment of national development and the need for the state to ensure that all international conventions, treaties and agreements to which Zimbabwe is a party are incorporated into domestic law.

The Constitution contains a comprehensive Declaration of Rights that protects the rights of every person, such as labour rights, access to information, administrative justice, environmental rights and freedom from arbitrary eviction, and health care, as well as food and water (Zimbabwe, 2013, sec 65-77). These rights can quickly be overrun by business operations in an environment in which investors are not socially responsible. This overrunning has already been observed in areas such as Marange (diamond extraction), Hwange (coal mining), Chisumbanje (ethanol production), Shurugwi (gold and chrome mining), Mutoko (granite mining) and Zvishavane (platinum and other minerals).

Environmental Management Act

The Environmental Management Act establishes the Environmental Management Agency, provides for principles of ecological management and outlines the environmental rights of every person. In essence, the Act guarantees every person the right to live in a clean environment that does not cause harm to health. It also provides that it is the right of every person to protect the environment for the benefit of present and future generations. Further, it provides that it is the duty of every person, in terms of the legislation, to participate in the implementation of reasonable legislative policy and measures that prevent pollution and environmental degradation, as well as measures that secure ecologically sustainable management and the use of natural resources, while promoting justifiable economic and social development.

Labour laws in the context of mineral governance in Zimbabwe

Zimbabwe has gone through deteriorating human and economic situations. The energy, unemployment and financial crises have had a toll on the majority of workers. With rising levels of unemployment, it becomes almost suicidal to demand adequate protection of human and labour rights in the mines.

The challenges concerning the mining industry have not been unique to the coal-mining industry; hence, there is a need to appreciate the broader extractive industry challenges beyond coal mining to get a fuller picture of the state of the extractive mining and mining labour in Zimbabwe. Gross human rights violations in the Chiadzwa diamond fields arose from the infamous days of Operation Chikorokoza Chapera in 2006. The Operation was a security clampdown on illegal diamond miners in the wake of a momentous diamond rush. Human rights reports highlight Operation Chikorokoza Chapera in the following terms:

> *The operation was marked by human rights abuses by the police, as well as corruption, extortion, and the smuggling of diamonds. Police coerced local miners to join syndicates that would provide the police with revenue from the sales of diamonds that the miners found. In seeking to end illegal mining and maintain control of the fields, police engaged in killings, torture, beatings, and harassment of local miners in Marange, particularly when police "reaction teams" carried out raids to drive local miners from the diamond fields. (HRW, 2009, p. 19)*

The coal-mining sector has seen severe challenges in areas such as Hwange. Reports of health violations and a lack of compensation for pollution, workers' labour rights violations and for community members burnt in unsecured coal pits have been well documented (Mlevu, 2016; CNRG, 2016). The legal and policy framework governing the rights of mineworkers in Zimbabwe is much more intensive than the general environmental rights outlined above. It is the implementation that is problematic. Zimbabwe, as a resource-rich nation, is beginning to take strides towards an alignment of the forces fighting for labour justice with the ones fighting for environmental justice. The local ecological justice movement is noticeable mainly, but there is no tangible solidarity between the labour and environmental justice movements. This lack of cohesion between such forces can be a weak link to the promise for a sustainable future for humanity.

The laws governing mineworkers include the 2013 Constitution of Zimbabwe, Labour Act. The Constitution of Zimbabwe provides for some progressive and extensive labour rights. Every person is guaranteed the "right to fair and safe labour practices and standards and to be paid a reasonable wage" (Zimbabwe, 2013, sec 65(1)). Furthermore, the constitution also guarantees the "right to participate in collective job action, including the right to strike, sit-in, withdraw their labour and to take other similar concerted action" (Zimbabwe, 2013, sec 63).

The Constitution is supported by the Labour Act, the primary objective of which is the promotion of social justice in the workplace and clarifying the constitutional fundamental rights and duties of employees and employers. As outlined above, the workers also have environmental rights that are guaranteed by the constitution and the Environmental Management Act.

At the international level, Zimbabwe is part of various International Labour Organization (ILO's) conventions, as well as the International Covenant on Economic Social and Cultural Rights (ICESCR). These laws provide for environmental justice in the workplace. Article 7 of the ICESCR provides: "The States Parties to the present Covenant recognize the right of everyone to the enjoyment of just and favourable conditions of work which ensure, in particular, safe and healthy working conditions." (OHCHR, 1966)

While conducting research on responsible investment in the Zimbabwean mining sector, the authors noted that "there cannot be responsibility in investment if human capital in terms of labour is not adequately catered for" (Ndamba & Chisaira 2016, p. 26). The labour rights of mineworkers in Zimbabwe are at their lowest, in line with the deterioration of the economy. While mineworkers do not fare well even in neighbouring countries, such as South Africa, industrial action in that country saw some improvement in terms of wages and working conditions since the Marikana massacre of August 2012. Despite the hardships, however, the importance of safeguarding labour rights cannot be overstated.

Mineworkers need to utilise their human right to collective bargaining as well as freedom of assembly and association, and hence create a practical and unified trade union. In 2019, mineworkers in Zimbabwe were organised in too many trade unions and which were ostensibly at loggerheads with each other. As at 2021, mineworkers were organised into the National Mine Workers Union of Zimbabwe (NMWUZ), the Associated Mine Workers Union of Zimbabwe (AMWUZ) and the Zimbabwe Diamond Workers Union (ZIDAWU). NMWUZ is an affiliate of the Zimbabwe Congress of Trade Unions (ZCTU), while ZIDAWU was formed in August 2012 and is registered as a trust.

Opportunities and challenges on law reform for a just transition

Overview

The calls to address climate change carefully while shifting from coal- and fossil-based industries to cleaner energy are well documented. Global treaties calling for a just transition for fossil workers and industries in the fight against climate change have been central to the international climate legal framework. In its preamble, the Paris Agreement (which was adopted on 12 December 2015 and entered into force on 4 November 2016), calls for state parties to take into consideration "the imperatives of a just transition of the workforce and the creation of decent work and quality jobs in accordance with nationally defined development priorities" (UN, 2015).

The aspiration for a just transition is however greatly dependent on domestic climate policy, as outlined in each state's nationally defined priorities. For instance, the Zimbabwe Nationally Determined Contribution (NDC) report outlines several clean-energy initiatives under consideration. These initiatives include an increase in large and mini-hydro power plants, construction of institutional biogas digesters, solar energy, ethanol blending and electrification of the rail system as well as the long-delayed search for sustainable energy alternatives to the curing of tobacco. However, most of these cleaner energy initiatives pose opportunities for Zimbabwe's energy workforce, especially if workers are retrained for greener jobs, such as energy workers in the coal sector being retrained to work in solar energy or refuse workers being trained to work in recycling projects. The whole narrative of ambitious cleaner energy projects will require climate financing, but this must be done in ways that empower the governments and tax-revenue systems of developing states and in ways that do not leave developing states tied up with debt.

The Paris Agreement has been bolstered by the UNFCCC CoP24 held in Katowice, Poland. CoP24 is instrumental in the just-transition and decent-jobs discourse. Despite being held in the traditional Polish coal heartland of Silesia Province, the conference focused on the just transition. A key output of the conference was the Solidarity and Just Transition Silesia Declaration, which was an essential document on the relation between climate change and labour justice that built on the Paris Agreement's desire to achieve a just transition (UN, 2018). The Declaration stresses that a "just transition of the workforce and the creation of decent work and quality jobs are crucial to ensure an effective and inclusive transition to low greenhouse gas emissions and climate-resilient development." The global climate change discourse has therefore moved a reasonably longer road towards a greener world but without leaving traditional workers and their labour rights and social justice expectations at the deep end (Chisaira, 2019).

The key determinant for relations of work and the impact of climate change are going to be derived from the broader societal arrangement of modern neo-liberal capitalism. It is therefore expected that most international discussions will centre on the preservation of the dominant capitalist economic and global system and its attendant problems and challenges, such as the lukewarm desire to deal with the causes of climate change or with changing the consumption and production levels in the industrialised world.

Scholars around the world have since observed that the transition to cleaner forms of energy or climate mitigation measures will not necessarily mean an improvement in worker welfare and rights. Jerry van den Berge, for instance, points out that:

> *Green jobs are not necessarily decent jobs. So, the creation of new, green jobs does not guarantee that workers will get new, decent employment from mitigation policies. For unions, it is important to seize the opportunities for new employment, while at the same time they must protect working conditions. (Berge, 2010)*

Such a just transition will need to see an overhaul of labour relations and labour laws so that workers remain in secure workplaces that are characterised by social justice and social democracy. Workers would then have a say on the ways the workplace is run and in the way, for instance, the air conditioning, workers' safety and insurance policies are discussed and formulated (Chisaira, 2019).

Opportunities

Energy is a critical aspect of modern life. The desire for energy must, however, be juxtaposed with the need to serve the people and save the planet in the era of climate change and climate injustice. The ever-present need for uninterrupted sources of energy coupled with the centralised nature of national power facilities in most Africa states, such as Zimbabwe, may be an opportunity in eventually achieving a Southern African energy transition. Elizabeth Gachenga notes this point while, however, stating that this may be a challenge to commercial viability:

> *An analysis of the performance of the electrical power generation utilities of most African countries demonstrates some of the challenges contributing to the inefficient use of energy. Most of the power utilities are centralised corporations whose commercial viability is not a priority, given the urgent need to provide access to the poor who are a majority. The lack of sufficient capital undermines the capacity of these utilities to operate efficiently. The challenges facing the energy sector have adversely affected efforts at embracing cleaner forms of energy. (Gachenga, 2016, p 188)*

Hence, there is a need for governments to prioritise cleaner energy development by the central power providers, such as the Zimbabwe Electricity Supply Authority (ZESA), established by the Electricity Act (Cap 13:05).

At present, Zimbabwe has adopted a National Renewable Energy Policy, which has the intended focus of improving the share of renewable energy in the overall energy mix and addressing issues of climate change. The policy also focuses on achieving the cost-effective implementation of productive energy sources, social upliftment through community involvement, gender equality and employment-generation.

The major opportunities for a smooth transition in the coal sector in the time of climate change stem from the importance given to the just transition principle at the national and international levels. As scholars have pointed out:

> *The Just Transition principle is fast becoming an accepted part of international climate change law and policy. At the domestic level, there are already moves in important policies such as the National Climate Change Response Strategy and the National Climate Policy to discuss the implications of the transition to renewable energy and the green economy on the socio-economic rights as well as on human needs. (Chisaira, 2019, p. 177)*

Hence, with joint work by trade unions, environmentalists and policymakers, there are greater chances and greater incentives for a just transition in the SADC and Zimbabwean fossil-fuel industries.

Challenges

The main challenges stem from a lack of financial resources as well as a lack of political will by global and national power holders to effectively lead society through a transition to cleaner sources of energy. Zimbabwe as a developing state needs adequate climate financing to ensure the adoption of sufficient renewable energy systems as well as the just transition. The same could be said for fellow states in Southern Africa whose most pressing needs would be food security, peace, employment creation and community development, rather than renewable energy.

There are also problems with the lack of democratic involvement of the workforce in the mining sector. As noted earlier in the research, there have been instances when workers were gunned down or lost their jobs merely for raising labour and wage-related grievances. Such expressions by mineworkers are entirely a part of the labour law regime in most Southern African states such as Zimbabwe and South Africa.

The other key challenge emanates from a political economy model where the interests of fossil industry owners are tied with those of political power holders. Hence, there is a noticeable reluctance to progress towards cleaner sources of energy that are perceived to be less profitable in the short term for the current energy corporations (Denning, 2019).

Conclusion

Climate financing for a just transition

The research has established that there is considerable legal and policy framework at the global national stage to manage environmental degradation, the shift from coal mining to cleaner energy, and on preventing mass unemployment and disaster or climate refugees. However, the aspirations of Zimbabwe and other Southern African states continue to be hampered by a lack of resources to enable an effective transition to better energy production and sharing.

The lack of resources is mainly caused by the reluctance on the part of industrialised states, such as the United States, to meet their obligations in the interests of climate justice. Locally, there are also potential transparency and accountability challenges with the management of climate financing and of the broader energy sector.

Building labour justice in the extractives sector

The extractives sector remains one of the most critical environmental areas, and mining labour is a significant feature. Mineworkers need to begin introducing campaigns for environmental justice as part of their advocacy for labour rights. Historically, mineworkers in Zimbabwe, through the many trade unions, were focusing on mere wage struggles and were not concerned much with environmental issues or the degradation caused by their labour-power. However, there is usually some connection when mineworkers fight for occupational health and safety (OHS), since OHS issues are environmental justice issues as well as labour rights.

For mineworkers themselves, the most viable and sustainable future in Zimbabwe can be attained through collaboration with groups that are courageously campaigning for environmental and economic justice in the mining and extractive sectors. These groups include mining-community rights groups, environmental-justice associations and even the so-called independent commissions like the Zimbabwe Human Rights Commission. Above all, mineworkers need to begin re-aligning their forces and working in harmony with each other as well as in solidarity with powerful mine unions beyond the borders. The current divisions in Zimbabwe's mining trade unions movement will not advance the cause of mineworkers or the global campaigns for a world that is free from environmental degradation and human rights violations.

Inclusion of mineworkers' lesser-developed communities in energy and environmental policy

The struggle for the full recognition and protection of human rights, and especially the often sidelined economic and environmental justice rights, is a critical element of national development. This realisation has been remarkable both throughout history and especially for indigenous and climate-injustice-affected peoples and mineworkers. The Solidarity and Just Transition Silesia Declaration and the ILO Convention Concerning Indigenous and Tribal Peoples in Independent Countries are very relevant in this regard, though a considerable number of African states have not ratified it.

The ILO convention indicates that states have the "responsibility for developing, with the participation of the (tribal and indigenous) peoples concerned, coordinated and systematic action to protect the rights of these peoples and to guarantee respect for their integrity" (ILO, 1989). To achieve this objective, the convention calls for measures that minimise gaps "in a manner compatible with their (indigenous peoples') aspirations and ways of life" (ILO, 1989). This provision is significant since indigenous coal workers and communities in most instances continue to suffer as a result of inequality and energy, economic and developmental gaps, regardless of the nature of the energy transition. Hence, there should be a means of developing a legal and policy framework that recognises the primary rights and expectations of the immediate miner and people communities. This recognition is beneficial to society if done sincerely.

Regarding development, therefore, there is need to look at possibilities of law reform, empowerment and capacitating of communal groups and institutions. There is also need to look at the protection of fundamental constitutional rights to public participation and consultation in regional and national river management.

Exploring greener alternatives to neo-liberalism in law and policy

While there is rampant poverty, the perpetuation and promotion of neo-liberal policy and law formulation within the post-colonial Zimbabwe states highlights the need for an alternative environmental development and policy formulation pathway. The free-market systems and neo-liberal economic and political governance systems have failed to deliver economic and environmental justice for most people (Phiri, 2012, p. 224). Hence, there is need for regional rebirth towards informed yet alternative pathways to the neo-liberal model. The most obvious choices would be the development of a participatory green economy that places people and the planet ahead of profits.

Transparency and political will

The protection of the environment and natural resources requires political will and commitments from the central and local government as well as environmental institutions. Anti-poor energy policies and laws, weak labour protection and a lack of political will to develop less pro-investor policies and more pro-community laws and policies can be said to be one of the reasons for the perpetual poverty, corruption and disempowerment of most communities in Zimbabwe (Arnall, 2014, p. 146).

Regional cooperation

An important consideration is that Zimbabwe is an integral part of the regional body, SADC. There is a need for the experience sharing and adoption by the SADC states of best practices that can be employed to develop an environmental-rights-sensitive response to the energy and climate crises within the SADC region. Such cooperation is per the principles of international law and can be a trigger for bilateral and multilateral development cooperation on related terms.

Empowerment of grassroots communities

There are several community associations and cooperatives around Zimbabwe's coal mining districts such as Hwange and Gokwe. These are mainly made up of farmers' villages. Laws can be used to empower these communities. Such ways can involve, among a host of other solutions, affirmative action to represent local community groups in local governance and coal mine community relations structures as well as alleviating the economic burden on local economic groups and workers by imposing affordable training programmes for a just transition. Empowering communities is one of the ways of ensuring that their vision for a sustainable and better environment is shared and achieved more straightforwardly.

Another critical initiative involves the participation of climate-injustice-affected communities in the law and institutional reforms at local governance levels. A change of district by-laws to include issues of transparency in contract negotiations with investors as well as an encouragement of community participation in the formulation of district by-laws and budgeting systems is beneficial to disadvantaged and energy-poor peoples. Consultation and free, prior informed consent initiatives will go a long way in catering for the concerns of climate injustice-affected or resource-rich communities. The discussion and public participation ought to be tangibly adopted and committed to as part of national and international environmental management policy formulation.

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4

Implementation of the Paris Agreement Technology Transfer Provisions among Sub-Saharan African Countries: A Legal Outlook of the Mining Sector

Mutuso Dhliwayo and Chantelle G. Moyo

Abstract

Globally, the urgency to act on climate change is gaining momentum, without sparing any sector of the economy. The preamble to the UNFCCC document, the Bali Action Plan and the Paris Agreement all note the critical importance of technology development and transfer accompanied by the provision of adequate financial resources and investment as a means of addressing climate change mitigation and adaptation actions. Sub-Saharan African countries that are at the frontline of climate change impact are also host to a significant proportion of Africa's carbon wealth; The wealth is at risk of being left stranded if they not effectively leveraged to further a sustainable industrialisation in line with the Paris Agreement. Therefore, finding practical and effective responses to the scourge of climate change will have profound repercussions at global, regional, national and community levels. The urgency to find solutions to this problem requires unparalleled, bold actions from governments, the private sector and civil society, especially in as far as the transfer of technology is concerned. This research paper focuses on how governments, the private sector and other actors in SSA are facilitating and accelerating environmentally sound technologies through legal and policy measures. It considers the international legal climate change regime and government policies within SSA, as to whether the existing frameworks warrant a reinterpretation or reconfiguration to address the major barriers and possible mechanisms that are key in positioning the extractive sector for adequate technology development and transfer.

Introduction

Without contestation, climate change is ranked as one of the most important challenges currently facing humanity. Its consequences are far-reaching and it will continue to be a major problem not only due to its long-term impact on sustainable development, but also due to its complex and ubiquitous nature. This observation found support in the Fourth Assessment of the Intergovernmental Panel on Climate Change (IPCC) and has been repeatedly expressed by the United Nations Secretary-General in different fora, which have sought to address pressing challenges facing civilisation as we know it (IPCC, 2000). SSA countries on their part are at the frontline of these climate change impacts while being host to a significant proportion of Africa's carbon wealth. Therefore, finding practical and effective responses to the scourge of climate change will have profound repercussions at global, regional, national and community levels. Moreover, social, economic and environmental policies aimed at tackling this challenge are indispensable since climate change affects all facets of society (UN, 2008). The urgency to find solutions to the problem requires unparalleled and bold action by governments, the private sector and civil society, especially in as far as the transfer of technology is concerned.

This research paper will focus on how governments, the private sector and other actors in SSA are facilitating and accelerating environmentally sound technologies through legal and policy measures. It considers the international legal climate change regime and government policies within SSA as to whether the existing frameworks warrant a reinterpretation or reconfiguration to address the major barriers and possible mechanisms that are key in positioning the extractive sector for adequate technology development and transfer.

Background to technology transfer in climate change

A global concerted effort to address the challenge of climate change can be traced to 1992 when UNFCCC was adopted. UNFCCC's long-term objective is stated clearly in Article 2 of the Convention, which is the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (UN, 1992). The fulfilment of this ambitious goal is impossible without moving away from the business-as-usual approach by both developed and developing countries; it can be attained through the use of fewer technologies that emit greenhouse gases (GHG).

The question of technology transfer has been contentious since the beginning of global climate negotiations. In 1992, under the UNFCCC, developed countries generally agreed to "take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to developing countries and to support the development and enhancement of (their) endogenous capacities and technologies" (UN, 1992). This commitment, while anchored on the principle of common but differentiated responsibilities and in accordance with their respective capabilities, has fallen short in meeting the desired objective (Diringer, 2009). It has also not been spared from severe criticism given the complexity and unwavering position within the negotiations (Burns, 2012).

A major challenge that has been faced in the context of developing countries is building sustainable, transparent markets for low-carbon solutions. The importance of accelerating the transfer of climate-friendly technology from developed to developing countries cannot be understated if the convention's objective is to be attained accompanied by predictable and substantial public finance (Barnard & Nakhooda, 2015). This task, in itself, requires complementary efforts on several fronts, including strong commitments by major developing countries on the kinds of national measures needed to generate genuine technology demand (Diringer, 2009).

The current warming levels that the world is facing have been attributed to historic emissions by developed nations, which ironically have the technical and financial ability to assist developing countries (Sullivan, 2011). In coining the definition of the term 'technology transfer', the IPCC explained that the term 'transfer' is in itself broad and inclusive. It includes the diffusion of technologies and technological cooperation of countries across the globe between developed countries, developing countries and countries with economies in transition. In a nutshell, technology transfer is a process of learning with the intention to understand, use and replicate technology, including the capacity to adapt to local conditions and integrate it to be used alongside indigenous technologies (IPCC, 2000).

The transfer of technology by developed countries to developing countries is imperative for the implementation of climate change mitigation efforts by developing countries' mining sectors. Seventy percent of African exports are noted to come from "oil, gas and mineral resources, accounting for about half of the Africa's Growth Domestic Product", while simultaneously providing the much-needed energy that drives economies in the absence of alternatives (UNU-INRA, 2019). On this note, the reduction of GHG emissions in the mining sector rests on the provision of affordable and reliable alternatives of clean-energy technologies for wind, solar, clean coal production and extraction and use, as well as efficient lighting (World Bank, 2008).

Historically, technology transfer was generally perceived as the transfer of machinery and equipment from developed countries, which usually were the producers, to the developing countries, usually the users, through aid, trade, foreign direct investment or licensing. However, with technological advancements at an unprecedented pace in the last decades, it has been shown that these transfers are technology payments and that this technology is entrenched in political and social institutions that have an effect on technology absorption.

Similarly, it is evident that technology can be absorbed contingent on the recipient country having a degree of domestic capacity (UN, 2008). For this reason, some developing countries have managed to compete in the marketplace because of technology learning and mastery. Nonetheless, many developing countries still lack the human and institutional capacities as well as the necessary infrastructure, which enables the effective transfer and absorption of innovative technologies needed in the fight against climate change.

The focus on technology transfer rather than on innovation is strategic, as it meets the demand from developing countries. Closely related to technology transfer is the transfer of financial resources to the South, specifically Article 11, which proposes the creation of a financial mechanism. This portrays the dual role of technology in the treaty, whereby North-to-South transfer is seen as a necessity to access technologies that have mostly been produced in developed countries (Dechezleprêtre et al., 2008). In practical terms, the development of technologies for climate change mitigation interventions shows that between 2000 and 2005, 60 percent of these technologies were developed in Japan, Germany and the United States of America and these technologies gradually found their way to developing countries (Glachant & Dechezleprêtre, 2016).

The roadmap of technology transfer in climate change negotiations: The Paris Agreement and beyond

International negotiations pertaining to technology and technology transfer have a long history. Technology development and diffusion is the fourth commitment of the Parties to the UNFCCC signed in Rio in 1992. According to UNFCCC Article 4.5, developed countries "shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and knowhow to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention." The UNFCCC also includes precise commitments by developed countries to support the development and enhancement of endogenous capacities and to transfer technologies to the developing world.

The mandate of developed countries to support developing countries in as far as technology transfer is concerned was further reiterated under the Kyoto Protocol. Developed countries were mandated to formulate "policies and programmes for the effective transfer of environmentally sound technologies that are publicly owned or in the public domain and the creation of an enabling environment for the private sector, to promote and enhance the transfer of, and access to, environmentally sound technologies." The convention and the Kyoto Protocol hence laid a foundation in terms of how technology-transfer discussions were to follow in subsequent negotiations (UN, 1998).

Technology transfer has been discussed at every COP from 1998. The first significant step was made in 2001 under the Marrakesh Accords. During the accords, the Technology Transfer Framework was concluded. The framework was guided by five working themes, which include technology needs assessments (TNAs), enabling environments, technological information, capacity building, and mechanisms for technology transfer. The responsibility for the implementation of the framework was given to the Expert Group on Technology Transfer, which was also established under the framework (Glachant & Dechezleprêtre, 2016).

The following significant steps were taken during COP13, which was held in Bali in 2007 where technology was one of the four pillars expected in the post-2012 climate change regime. After COP13, the Poznan Strategic Programme on Technology Transfer was adopted in 2008, during COP14, and it allocated USD 50 million to the funding of TNAs as well as pilot technology projects (GEF, 2010). In 2010's COP16 in Cancun, Mexico, a mechanism comprising the Technology Executive Committee (TEC) and a Climate Technology Centre and Network (CTCN) was devised. The TEC is the policy arm of the technology mechanism, while the CTCN would focus on stimulating technology cooperation, development and transfer to developing country parties, all while under the UNFCCC.

The Paris Agreement, adopted in December 2015, is a build-up of the conversation on technology and technology transfer since 1992. Under the PA, the role of the technology mechanism is confirmed and the main innovation under the agreement is the establishment of a technology framework, which provides the "overarching guidance to the work of the Technology Mechanism in promoting and facilitating enhanced action on technology development and transfer in order to support the implementation of this Agreement" (UN, 2015, Article 10). The long-term vision for technology development and transfer, shared by all the parties, is a full realisation of technology development and transfer to reduce GHG emissions and improve resilience to climate change (UNFCCC, 2015).

Beyond the PA, the technology mechanism must promote and facilitate better action on technology to assist countries to achieve the purpose and goals of the agreement. This will be done while recognising the import of rapidly accelerating transformational attitudes towards climate resilience and low GHG emission development. Moreover, actions and activities under the technology mechanism must expedite the implementation of mitigation and adaptation actions which will be identified using planning tools and processes, such as the development of strategies for long-term low GHG emission, nationally determined contributions (NDC), technology needs assessments, technology road maps, national adaptation plans and other relevant policies.

Technology transfer, sustainable development and mining in Southern Africa

Africa is rich in natural resources. The continent is endowed with 7.3 percent of the world's gas reserves and 7.2 percent of the world's oil reserves (BP, 2019). An estimated 70 percent of African exports are derived from the oil, gas and mineral sectors, and these account for about half of Africa's gross domestic product (GDP), as well as contributing significantly to government revenues. In sub-Saharan Africa alone, it is estimated that recoverable energy resources include 115.34 billion barrels of oil and 21.05 trillion cubic feet of gas (UNU-INRA, 2019). New oil and gas discoveries are constantly being made and recently have been discovered in Mozambique, Zimbabwe, South Sudan and Ethiopia; with the Ogaden Basin alone containing 8 trillion cubic feet of natural gas reserves, worth a potential USD 7 billion a year, once at full capacity. From 2000 to 2012, the expansion of the mineral extractive sector increased foreign direct investment (FDI) into Africa from USD10 billion to USD 50 billion (Halland et al., 2015).

The mining sector in the Southern African region underlies considerable intra-regional flows of specialised equipment, skills, engineering services and knowledge. South Africa, which historically has the most technologically advanced mining input cluster in comparison with Zambia and Zimbabwe, has developed very strong linkages to the SADC region (Fessehaie, 2015). As such, South Africa's prominent role in the region has numerous dimensions, which include investment, exports and skills, and it attracts skilled labour and arguably has the most developed knowledge economy in the region (Fessehaie, 2015; Ferranti et al., 2002, p. 16). Simply put, South Africa is a mining supply 'hub' for the region in as far as capital, services and equipment goes, in which case much originates from developed nations (Fessehaie, 2012).

The historical experience of resource-rich countries proves that natural resource sectors, like the extractives, have catalysed important processes of growth, productivity, technological innovation and forward and backward linkages. Investment in human capital and good institutions are critical for such processes. Before technological transfers can occur, regionally or internationally, these factors have to be in place and investors must have confidence in the institutions that create an enabling environment for the adaptation of the technologies.

Since climate change and higher GHG emissions adversely affect sustainable development, especially in developing countries, it is important to bear in mind that efforts to reduce the emissions and minimise the impact of climate change are expensive. They also negatively affect the economic development of these countries. Appropriately designed efforts under mitigation and adaptation can buttress sustainable development goals and reduce developers from remaining with stranded assets that ultimately do not yield much in the way of results.

The preferred strategy for developing countries, like Zimbabwe, South Africa and Zambia, which have a wealth of fossil fuels intended to be significant contributors to these countries' economic growth, would be to take advantage of the synergies already in existence between climate change and sustainable development, thereby promoting both. This provides developing countries an opportunity to undertake sustainable development programmes in the extractives sector and at the same time effect climate change mitigation or adaptation.

To achieve the targets of the Paris Agreement on climate change, integrated assessment models estimate that Africa must forego burning 90 percent of known reserves of coal, 34 percent of gas and 26 percent of oil (McGlade & Ekins, 2015). The 2019 Global Outlook Report estimates that, if the trend of resources extraction continues unchecked, most countries will fail to fulfil the goals of the Paris Agreement and SDG 15. However, the rate of mineral extraction is reported to have increased worldwide, and to a great extent in Africa, since its economic growth trajectory depends on these resources (UNEP, 2016; Jegede, 2016). In fact, nine of ten countries in sub-Saharan Africa depend on commodities (including fossil fuels and minerals) for projected growth and revenues to fund government expenditure for developmental goals (UNCTAD, 2019).

Meanwhile, resource exploitation has historically served foreign and elite interests; many resource-rich countries in Africa have not yet managed to capitalise on resource rents in a manner that serves broader sustainable development. As such, Africa's resources have been 'stranded' in a sense from the colonial period onward, as the real value of resource wealth has not brought prosperity to the wider populations but to a select few (UNU-INRA, 2019).

Undertaking sustainable development actions calls for a full consideration of the three dimensions of sustainable development, namely the social, economic and environmental dimensions. Factors to be considered in the social aspect include the preservation of culture and heritage, poverty reduction, popular consultation and empowerment to enable popular participation (Fessehaie, 2015. Within the environmental sector, consideration must be extended to the reduction of pollution, balanced use of natural resources and development of resilience to known and foreseen environmental shocks. In the economic sector, factors to be considered are economic growth and efficiency while preserving political stability. Sustainable development is also important in conversations around technology transfer because issues such as inter-generational equity and equity among different social groups cannot be overstated. The technology that is transferred must use equity and fairness as guiding principles for a development paradigm. Actions undertaken without a consideration of sustainable development can affect the success in achieving climate change stabilisation IPCC, 2000.

Therefore, for any climate change strategy to be effective, it must include a portfolio of policies, measures and technologies that assimilate development, equity and sustainability. Moreover, decision-making in a sustainable development context requires an intense economic analysis of climate change by including all co-benefits. This is due to the fact that climate change threatens to increase the gap in the distribution of goods and services between generations and the rich and poor. Any effort at mitigation and adaptation must therefore have these considerations at the fore. Moreover, a consideration of resource-rich countries suggests that "the broad lesson is that the inherent character of resources does not matter for resource-based development, but rather, the nature of the learning process through which economic potential is achieved" (Wright & Czelusta, 2007). Learning and innovation are key determinants in the creation, distribution and use of new resources (Andersen, 2012, p. 291). Sustainable development is also a factor in whether or not technological transfers occur in the mining sector in Africa.

Africa's developmental challenge and worldview on carbon

For most African countries, natural resource sectors such as oil, gas and mining are important parts of the economy. Harnessed correctly, these natural resources have the potential to be huge drivers for development in the continent. Through the exploitation of this natural resource base, converting underground minerals into human and physical capital for inclusive growth, Africa can become a massive factory for production by 2050 (JICA, 2013, p. 117). This will be the same trajectory for development as characterised countries like Britain and the United States of America in the second half of the 19th century, and countries like China and Australia in the 20th century.

The development of Africa and extractive industries remain intricately linked. This is due to the fact that, for most African countries, the extractives sector constitutes a significant proportion of the formal economy. Moreover, for several mineral resources, Africa is an important player on the world stage. This is largely attributable to the continent's historical legacy, where many of today's extraction techniques were first developed, for instance, copper and cobalt in Zambia, gold, platinum and diamonds in South Africa, bauxite in Guinea and liquefied natural gas in Algeria (UNECA, 2011). Mining, specifically, is among the most important sectors to sub-Saharan Africa's economy, according to its contribution to exports, revenues and GDP (Banerjee et al., 2015). From 2000 to 2011, petroleum and mineral resources made up an average of more than two-thirds of exports in the entire region (Altenburg & Melia, 2014). For the major oil and gas producers in the region, revenue from these fossil fuels has consistently accounted for 50-80 percent of government revenues over the past decade.

While the extractives sector has massive potential for the economic development of the country, fugitive emissions from oil, gas and coal mining operations account for 7.3 percent of total GHG emissions in sub-Saharan Africa (IRENA, 2014, p.14; IEA, 2014). Fugitive emissions are a result of the liberation of stored GHGs during mining processes. For instance, methane from coal mining has been flared, emitting significant GHGs. Methane and nitrous oxide also escape through oil and gas production, through leaking equipment, natural gas transmission, and distribution and storage facilities (Hogarth et al. 2015).

Extractive industries are highly capital-intensive and neither create many jobs nor contribute significantly to the development of skills and human capital (JICA, 2013, p. 120). This is not only true in Africa, but it also rings true for other parts of the world. Therefore, mining and oil and gas operations have limited forward or backward linkages to the rest of the economy and often have been perceived as virtual enclaves with little impact on the economies of host countries, other than payment of taxes and royalties (JICA, 2013, p. 120). This leaves Africa in a difficult position, having numerous natural resources and poverty beyond comparison. However, extractive industries have a very significant impact on the physical environment because of the operations involved in extracting the ore and disposing of tailings (mining waste). Significant impacts have also been noted in local communities. While these impacts can be beneficial, for the most part, they have tended to be damaging, particularly during the construction phase.

Whatever the rate of Africa's transition to a low-carbon economy, other countries will be looking towards new energy technologies in an effort to mitigate the impact of climate change in various sectors, including the extractives sector. Without the relevant infrastructure and technologies to transition, Africa risks being technologically 'locked out' and unable to honour commitments under international instruments designed to lay out a plan of climate action, like the Paris Agreement

(Burrows, 2018, p. 18). Equally troubling is the prospect that, should sub-Saharan Africa look to bolster fossil-fuel demand through intra-regional trading, it could find itself cut off from regions that are moving to new and cleaner technologies. In the worst-case scenario, Africa could be pushed out from the fourth industrial revolution and essentially become a dumping ground for old technologies and unwanted waste (Bos & Gupta, (2019).

In sum, this section shows the enormous mineral wealth that Africa, and indeed sub-Saharan Africa, boasts of. While these resources have been singled out to be potential avenues for propelling development in Africa, their extraction produces fugitive emissions. High levels of GHG emissions in industries that drive most economies in African countries, like the extractives, impede global efforts to reduce GHG in an effort to mitigate the consequences of global warming. Therefore, technologies that enable the functioning of these industries with minimal GHG emissions produced are more of a need rather than a want in the African context.

Barriers facing mining companies to effective technology transfer in developing countries

Technological change or transfer demands an enabling environment for it to successfully occur. Such transfers happen within a broader context of socio-economic factors; for instance, prices of energy or specific levels of infrastructural development can play significant roles in shaping technological change and in determining what kinds of technologies become commercialised in a certain context. However, there are multiple barriers confronting the mining sector that can impede the successful transfer of technologies in developing countries. These barriers can be summed up as follows:

- Lack of information – this includes the lack of understanding of the role of developed and developing countries as well as international institutions' past technology-cooperation agreements. Furthermore, the lack of research and development investment results in inadequate science and educational infrastructural development (UN, 2008).
- Market and financial barriers – these barriers are frequently present due to a shortage of financial resources and a lack of developed markets for the technology. Common in developing countries is lack of finance caused

by poor macroeconomic status, as a major barrier to technology transfer. Underdeveloped financial sectors, high or uncertain inflation and interest rates, high import duties, and uncertain taxes and tariffs make such investments in developing countries high risk. Therefore, markets may actually not exist for intended technologies due to such factors as a lack of financial institutions or systems that ensure investments are in place for the use of the transferred technology, a lack of confidence in commercial or technical viability, limited or no manufacturers, and a lack of consumer awareness and acceptance of the technology (UN, 2008).

- Regulatory systems – the most important barrier to mention in the technology transfer discourse is the regime governing intellectual property rights (IPRs) in developing countries, a lack of supporting frameworks and policies including standards for the implementation of environmentally sound technologies, low or subsidised conventional energy prices resulting in negative incentives to switch to renewable energy technologies, and a lack of access to relevant and credible information on potential partners to allow for the timely formation of effective relationships that can enhance the penetration of environmentally sound technologies (UN, 2008).
- Infrastructural development – this includes the design of cities, transport systems and utilities, as well as their flexibility in permitting the adoption of alternative technologies, lifestyles and production systems (UN, 2008).
- Social and political structures – this includes the role of the public in decision-making, where the power in institutional and social relationships lies, the presence of formal and informal alliances involving the government, the relationship between government, media and the citizens, as well as the allocation of roles within communities and households.
- Culture – this encompasses cultural diversity, the role of technology in terms of material consumption to establish individual identity, tendencies that encourage cooperation and competition and conformity distinction.
- Psychology – this includes the understanding, awareness and attitudes relating to the causes of energy efficiency, impact and what changes in technology mean and how they impact lifestyles.

Challenges facing technology transfer in Southern African countries

Zimbabwe

Historically, Zimbabwe's mining sector was regarded as well-developed through upstream and downstream industries, but the economic crisis in the early 2000s adversely affected the sector, as capacity utilisation declined from approximately 80 percent in 2000 to 10 percent in 2008 and 26 percent in 2015 (Jourdan, et al, 2012; Fessehaie et al., 2016, p. 5). One of the biggest challenges so far as technology transfer is concerned is the lack of technical skill because, since the early 2000s, there has been a large-scale loss of skilled labour, supplier firms and teaching and technology institutions. The Zimbabwe Chamber of Mines estimates that over half of the industry's skilled personnel emigrated from the country since 2007 and this skills gap makes it a challenge to transfer relevant technologies in the mining sector (Hawkins, 2009).

Since 2010, foreign direct investment inflows into the mining sector have been consistently low, with bits and pieces of imports in capital equipment. The mining sector is currently perceived to be the main driver of economic recovery in Zimbabwe; the World Bank argues that the growth prospect for manufacturing rests mainly in domestic demand, particularly in the resource sector (World Bank, 2014, p. 26). Although manufacturing is diversified compared to other African countries, firms have downsized considerably and import penetration in the supply chains is high (World Bank, 2014, p. 26). Davies, Kumar and Shah (2012, p. 8) posit that supply-side restrictions are now more critical than demand-side ones, as firms operate obsolete machinery, operate in a high cost and volatile environment because of regular (often day-long) power outages, struggle to access finance and have unreliable supply chains.

As part of a raft of its responses to integrate lower GHG emitting technology in the industrial sector, Zimbabwe has a number of laws, policies and strategies. These include the Constitution, the National Environmental Policy and Strategies, National Climate Change Response Strategy, National Climate Policy, the Environmental Management Act, Zimbabwe National Energy Policy, Renewable Energy Policy, and the recent Long term Low Greenhouse Gas Emission Development Strategy (LEDS) (Zimbabwe, 2013; 2009; 2014; 2002; 2012; 2019; 2020). All these legal instruments aim to steer the developmental trajectory of the nation that adopts a low-carbon development pathway that adopts "new and emerging technologies and innovations that are relevant and dynamic in offering adaptation and mitigation solutions" (Zimbabwe, 2017).

The anchor of Zimbabwe's climate response strategies is the 2013 Constitution (Zimbabwe, 2013). Section 73 affords every citizen environmental rights, which include the right to an environment that is not harmful to their health and well-being and to have the environment for the benefit of present and future generations, through reasonable legislative and other measures that prevent pollution and ecological degradation and secure ecologically sustainable development and the use of natural resources, while providing economic and social development. This key principle embraces the notion of absorbing the necessary technology that can promote the notion of development that is sustainable and ensures future generations can inherit a planet that is habitable.

Key towards implementing constitutional aspirations is the Climate Change Response Strategy (CCRS) that identifies the importance of technology transfer in as far as climate action is concerned. The CCRS notes that a total of 574 million would be needed to finance the technology-transfer needs of the nation. The mining sector is identified as one integral area where technology transfer is critical as the installation of clean technology can result in the capture and storage of carbon while simultaneously making end products sold at competitive prices (Zimbabwe, 2014, p. 58; 2019, p. 43).

The Zimbabwe policy responses to the challenges of climate change and its impact on the economy are consolidated in the LEDS. The LEDS identifies that the main source of GHGs emissions in the country is as a result of coal that is used in power generation and industry, diesel and gasoline for transport and liquefied petroleum gas (LPG) for industrial and domestic use (Zimbabwe, 2020, p. 21). The adoption and implementation of energy-efficient electric motors in the mining sector is identified as one of the necessary mitigation measures that will result in savings or revenue generation while mitigating climate change (Zimbabwe, 2020, p. 21). The same goes for cement production, which requires increased clinker substitution with fly ash and blast-furnace slag (Zimbabwe, 2020, p. 32). It is important to reiterate that the necessary technology for the production of energy-efficient electric motors is resident in developing countries, thus the importance of the transfer.

Despite having all these policies and strategies as responses to the country's technology transfer needs, there are some gaps and inconsistencies. For example, while the Renewable Energy Policy is promoting the uptake of renewable energy, the Energy Policy promotes all sources of energy including those that are not renewable and are among the greatest contributors to GHG, like coal. Currently, the government of Zimbabwe is in the process of establishing a 2000-megawatt coal power plant at Sengwa Mine in Gokwe, financed to the tune of USD 3 billion by China while expanding the Hwange thermal power plant (Maravanyika, 2020). These are high-climate-risk projects that will significantly contribute towards the rise in GHG emissions and are very much contrary to the country's commitment under the Paris Agreement. The other policy gap is that the main framework law for environmental management in Zimbabwe, the Environmental Management Act, does not cover GHG emissions' reporting, let alone reporting on climate mitigation and its effects, and thus sought to be remedied through the proposed climate change act that is in the pipeline (Zimbabwe, 2020, p. 32).

South Africa

South Africa has a longer history of mining and the economy of the country has mushroomed around that sector. Although this is the case, a significant level of diversification from the sector has occurred in the country, in comparison with Zimbabwe and Zambia. This diversification has taken on a capital- and energy-intensive quality, as mineral processing sectors have emerged to dominate the economy for decades as part of the manufacturing sector (Fessehaie et al., 2016, p. 6). South Africa's, diversification is due to the confidence in the sector from infrastructural development, technical skills and access to finance that make it an easy candidate for technology transfer. Conversely, the country's mineral industry also relies on imported technical and engineering skills from the region (Fessehaie et al., 2016, p. 6).

Of all the countries in Southern Africa, South Africa is perhaps the only country that has the most comprehensive response to the climate change crisis, through its constitution (*The Constitution of the Republic of South Africa, 1996*), laws and policies. This response is rooted in its very progressive constitution and its comprehensive framework legislation, the National Environmental Management Act (NEMA). Both the constitution and the NEMA have a provision on environmental rights, guaranteeing the right to a clean and healthy environment that is not harmful to one's health or well-being, which greatly influenced the Zimbabwean text.

Importantly, section 23(A)(c) of NEMA encourages the minister to promote integrated environmental management through the "adoption of environmentally sound technology". Environmentally sound technology is one that promotes principles of sustainable development that takes note that the exploitation of non-renewable natural resources should be done in a responsible and equitable manner that takes into account the consequences of the depletion of the resource." Technology transfer of alternatives would greatly assist the minister in making decisions that result in the advancement of these aspirations in the draft Climate Change Bill that advances carbon budgets, which would severely impact coal mining and use companies.

There have also been some cases in South Africa that have been litigated related to climate change and its related link to mining activities. For example, *Earthlife Africa Johannesburg v. the Minister of Environmental Affairs and Others* (2017) and *Trustees for the Time Being of GroundWork v. Minister of Environmental Affairs* (2017), *ACWA Power Khanyisa Thermal Power Station RF (Pty) Ltd and Others* (2017) are some cases that recognise the intricate relationship that exists between mining activities and climate change. In these cases, environmental impact assessment (EIA) licences had been issued without considering the climate change impact of these coal-fired power stations. The courts considered the licensing of coal-fired power plants without considering their climate change impact and, in both cases, the courts ruled that the climate change and environmental impact of these coal-fired plants had to be considered as part of the EIAs. It was further held that taking into consideration the climate impact was one of the ways of fulfilling South Africa's commitments under the Paris Agreement. While these cases indicated the importance of ensuring a balancing act between mining and the climate nexus, the provision of alternative energy at a similarly low economic cost as that provided by coal mining can be attained through the necessary technology transfer.

South Africa's mining inputs cluster, which is inclusive of the private sector through global and domestic agreements, is supplying capital equipment and engineering services to mining firms across the region. Often these services are supplied through relationships with engineering, procurement, construction and management (EPCM) firms. These are under contract with mining companies in the region for greenfield and brownfield projects and usually tap into their suppliers in South Africa to carry on these projects (Fessehaie, 2012). South Africa's presence in established markets is remarkable, as the share of capital-equipment imports sourced by South Africa amounted to 37 percent in Zambia and 57 percent in Zimbabwe.

Policy certainty, access to finance, skilled labour and a progressive culture, so far as technological advancements are concerned, make South Africa better than other countries in the region for technological transfer in the mining sector. However, emerging problems like the energy crisis, where load-shedding has become the norm, can be a barrier to such transfers.

WWZambia's linkages to development strategy, as far as their major mineral resource, has been copper mining. Since 2007, investment in copper mining has been on the increase given the incentives created under the Multi-Facility Economic Zones and Industrial Parks that resulted in the building of an industrial park in Chambishi, Copperbelt Province. However, the mining of copper has not resulted in the much needed skills development; it becomes an impediment to technology transfers, regionally and internationally (Fessehaie, 2012).

With the same ethos as Zimbabwe and South Africa, Zambia's constitution, in Article 112 (h), states that "the State shall strive to provide a clean and healthy environment for all". This mandate is undertaken on a day-to-day basis by the Zambia Environmental Management Agency in terms of the Environmental Management Act that warrants the prohibition of using technology for producing products that can cause harm to the environment Zambia, 2012, sec. 44). It has been documented that the mining sector in Africa is utilising obsolete and high-emitting technology, which causes harm to the environment and can be addressed through necessary technology transfers from developed countries, affecting all countries on the planet.

The objective of the Government of Zimbabwe, through the national policy on climate change, is thus to "develop and promote appropriate technologies and build national capacity to benefit from climate change technological transfer" that is in place through the provision of incentives (Zambia, 2016, section 7.3.5.1). The text and content in the existing legal framework indicate the desire of African countries to support international efforts in curbing climate change. However, they lack the necessary means at some levels for the undertaking, regardless of their efforts to attract knowledge.

Notwithstanding high-level political desire by the Government of Zambia to attract technology transfers, the upstream linkages are not clearly identified in Zambia's industrial policy framework, which includes the 2008 Commercial, Trade and Industrial Policy and the 2012 Strategy for the Engineering Manufacturing Sector. The 2012 Strategy Paper on Industrialisation and Job Creation aims to operationalise section 13 of the Mines and Minerals Development Act to support local manufacturing and procurement in the mining sector. However, this is in the same group with a very large number of other priorities, making it difficult to put it higher in the cluster. Interviews with key stakeholders highlighted three aspects of industrial policy, making technology transfer an uphill battle. These include a lack of clear policy objectives, a lack of coherence between various policy instruments, and organisations and poor implementation (Kasanga, 2012). These weak policy initiatives essentially led the private sector to take a leading role on the issue of local content.

The Zambia Association of Manufacturers (ZAM), the industry body, has over the years driven the local-content agenda with little support from the government. The Zambia Mining Local Content Initiative is a product of a memorandum of understanding between ZAM and the Chamber of Mines. The main activities of the Local Content Initiative revolve around addressing information gaps, through an online business-to-business platform, and conducting a capacity assessment of potential suppliers that will be assisted by targeted business development services. This initiative could improve the country's mining sector to a point where an enabling environment for technology transfer could be created.

Conclusion

Africa is endowed with the natural resource base to make it a potential economic giant compared to other continents. This research paper has shown how the extractives sector is one of the important development drivers of the continent. It also showed how the extractives sector is also a major contributor to GHG emissions; left unaddressed, these levels of emissions (originating from the sector), will be an impediment to the common global efforts at reducing GHG in an effort to mitigate the consequences of climate change. To address these concerns, the Paris Agreement makes provision for technological development and transfer, which creates enabling environments to reach the common goal so far as climate change is concerned.

A study of three countries in the sub-Saharan Africa region, namely Zimbabwe, Zambia and South Africa, shows the challenges prevalent in the mining sector that make technological development and transfers difficult. They include a lack of information, lack of markets, poor regulatory systems, cultural barriers, and social and political structures. While these challenges were identified as common in the study countries, and indeed most countries in the continent, South Africa was singled out as one of the countries that have invested in technology advancements and, as such, is a trusted and respected player in the extractives sector in the region and indeed on the continent.

Recommendations

In proffering recommendations, there is no one-size-fits-all. However, a starting point in creating environments that can facilitate technology development and transfers to the region will desire the removal of the barriers facing mining companies to effective technology transfer in developing countries, providing capacity building, undertaking information campaigns, review of regulation and standards in existence, addressing the intellectual property rights conundrum and the provision of finance for technology transfer, and fostering technology partnerships, agreements and sectoral approaches.

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Mitigation and Adaptation to Climate Change in Extractive Industries: A Case Study of Malawi

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Abstract

This paper draws from existing research to establish the link between climate change and the extractives sector in Malawi and is therefore based on a previously commissioned study. The objectives of the study included the following: understanding how climate change has impacted the extractive sector in Malawi and how thee impact will likely evolve; assessing the current and potential role of the extractive sector in climate change mitigation and adaptation in Malawi; and, identifying some of the national and regional policy levers for the Malawian government and companies to advance climate mitigation and adaptation. Conducted through a literature review of available research, key informant interviews and case-study analyses, the study demonstrated that climate change has had an impact on the extractive sector and that the sector contributes to increased national vulnerability to the consequent impact. The study also found barriers to and incentives for the possible contribution of the extractive industry to sustainable development. Based on these findings, the study recommended that existing policies, regulations and development processes should be climate-proofed, investment should be made in research and development to drive innovation for climate mitigation and adaptation, and financial barriers to climate management should be removed to enable appropriate technology investment for adaptation and mitigation.

Introduction

The imminence of the global climate crisis has been well supported by various studies and research reports documented over the last few decades. Some of the most authoritative documents on the impending crisis are the Assessment Reports by the Intergovernmental Panel on Climate Change (IPCC) produced from 1990, which have highlighted climate change as a global challenge and called for intergovernmental cooperation to address it. In the Fifth Assessment Report (AR5), the IPCC states that continued emission of GHGs will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems (IPCC, 2014, p. 8). This assertion has necessitated a comprehensive look into the causes and contributors to continued anthropogenic GHG emissions, which are mainly driven by population size, economic activity, lifestyle, energy use, land use patterns, technology and climate policy (IPCC, 2014).

Through the Paris Agreement, the world leaders committed to limit the increase in the global average temperature to "well below 2°C above pre-industrial levels" and to pursue efforts to limit the temperature increase to 1.5°C (UNFCCC, 2016). This commitment has clear implications on the causes and contributors to the GHG emissions and the usual way of doing business. Globally, economic activity and population growth have continued to be the most important drivers of increases in carbon dioxide (CO_2) emissions from fossil-fuel combustion (IPCC, 2014). Achieving the Paris Agreement figures would therefore have a significant impact on the fossil-fuel and extractives industry.

At the same time, the consideration of a world without fossil fuels requires the development of technologies that will be sourced from the extractives sector. In this discussion then, the extractives sector comes out as both a contributor to the climate problem and the solution for addressing global climate change impacts. With many developing countries like Malawi still working towards growing their economies, there are many questions regarding the implications of this transition on their development goals in the near future.

Understanding climate change

Climate change is a global problem affecting human beings at an unprecedented scale. It is defined as a change of climate that is attributed directly or indirectly to human activity altering the composition of the global atmosphere and which, in addition to natural climate variability, is observed over comparable time periods (UN, 1992). On a global scale, there is overwhelming evidence that the average global temperature has increased by about 1.4˚ F over the past 100 years (AAAS, 2017. The result of this is rising sea levels and an increased frequency of some types of extreme events, such as heat waves and heavy precipitation.

Climate change can be naturally induced by internal or external fluctuations of energy in the climate system or through anthropogenic factors, which are essentially human behaviour that increases concentrations of GHGs in the atmosphere. Since the 19th century, human-induced CO_2 emissions from fossil-fuel combustion, cement manufacture and deforestation have disturbed the balance, adding CO_2 to the atmosphere faster than it can be taken up by the land biosphere and the oceans (AAS, 2015, p. 12). The dominant cause of the increase in the CO_2 is the burning of fossil fuels. Over the last two centuries, the growth of fossil-fuel combustion has been closely coupled to a global growth in energy use and economic activity. Fossil fuel emissions grew annually by 3.2 from 2000 to 2010 (AAS, 2015).

While it is a global phenomenon, climate change often expresses itself in local and regional shocks and trends impacting vulnerable systems and communities (AAS, 2015). The contribution of Africa to global GHG emissions is minimal, at only 3.7 percent of global emissions as of 2017 (Ritchie & Roser, 2017). However, a combination of geographical and economic factors combined with high dependence on climate-sensitive sectors, such as agriculture, make African countries highly vulnerable to the adverse effects of climate change. This vulnerability compromises the continent's development and threatens millions of Africans and their livelihoods. According to current estimates, the negative effects of climate change are already reducing Africa's GDP by about 1.4 percent, and the costs arising from adaptation to climate change are set to reach an annual 3% of GDP by 2030 (AfDB, 2019).

Key principles in the management of climate change

Climate change mitigation

Climate change mitigation is one of the pathways to the management of climate risks and climate impact. Climate change mitigation refers to the efforts to reduce or prevent GHG emission in order to reduce the effects of global warming, which results in extreme weather events (Malawi, 2016, p. 10). Since about three-fourths of the increased radiative forcing of anthropogenic GHGs is due to CO_2, our highest mitigation priority should be to reduce the CO_2 emissions (AfDB, 2019). The IPCC centres this shift around the key sectors of energy and land use and has recommended various pathways to mitigation within the parameters of:

> *... energy resources like biofuels, energy supply and conversion technologies, energy consumption, and supply and end-use efficiency ... agricultural productivity, food demand, terrestrial carbon management, and biofuel production ... climate policies such as carbon pricing, and technology policies such as research and development funding and subsidies. (Rogelj et al., 2018)*

Since most of the CO_2 emissions come from the burning of fossil fuels, the reduction of energy-related CO_2 emissions remains a key priority on the global mitigation agenda Sachs, 2015).

Climate change adaptation

Climate change adaptation is defined as the process of adjustment to the actual or expected climate and its effects (Noble et al., 2014). It is the moderation of human systems to reduce the negative impact of climate change and take advantage of new opportunities for sustainable development (Noble et al., 2014). Scientists have posited that the current levels of GHGs have not yet manifested their maximum impact. This means that, even if GHGs were currently mitigated to the point of zero net emissions, the increased impact of climate change would still be seen, as the existing emissions take effect. This is very grim, but also tells that humans need to learn to live with climate change, hence adaptation. With great diligence and global cooperation, it may be possible to keep the global average temperature from rising by 2°C above the pre-industrial level; yet, even so, a 2°C rise will result in massive changes to the climate system, including more droughts, floods, heat waves and extreme storms (Noble et al., 2014). Climate change adaptation, therefore, enables identification of a range of actions that can be taken to increase resilience to the actual or expected climate and its effects.

The nexus between climate change and extractive industries in Malawi

Malawi's climate change trends and projections

Malawi is often described as a poor country dependent on rain-fed agriculture for its agro-based economy. Over the years, the increasing vulnerability of the country's economy to weather-related shocks has been added to this narrative. The World Bank's climate profile of Malawi states that it is a country particularly prone to adverse climate hazards, including dry spells, seasonal droughts, intense rainfall, ravine floods and flash floods.

In 2015, Malawi ranked third among the ten countries most affected by climate change in the world (AfDB, 2019). Droughts and floods have increased in frequency, intensity and magnitude over the past 20 years. This vulnerability has been seen with the occurrence of floods in January 2015, a year of drought in 2018, and, most recently, a tropical cyclone, Cyclone Idai, in March of 2019 (Irish Aid, 2017; Concern Worldwide, 2020). The Malawian government estimated that the cyclone and associated floods affected over 975,600 people (5.4% of the population), displaced 86 976 people (0.5% of the population) and killed 60 people; 288,371 houses were damaged or destroyed and the effects from this disaster cost an estimated USD 220 million (Concern Worldwide, 2020).

The observed climate variability and change in Malawi has been consistent with the global trends and in SSA. The climate of Malawi is greatly influenced by topography and the presence of Lake Malawi, a huge water body (29,600 km^2) that covers nearly two-thirds of the country's length (Wood & Moriniere, 2013). The mean annual minimum and maximum temperatures range from under 12°C to over 32°C (Wood & Moriniere, 2013). The 1980s recorded some of the highest surface air temperatures in recent years, closely followed by the 2000s, raising fears in many quarters that climate is already changing at a rate that is faster than at any other time in the past. These changing climatic conditions have normally been associated with the effects of El Niño (Wood & Moriniere, 2013).

According to the World Bank climate profile of Malawi, the average annual temperature in the country is projected to increase by 1.1°C to 3.0°C by the 2060s. The National Vulnerability Assessment projects that, for the period 2020-2040, the lowest increases in maximum temperature are likely to take place during January and February, with changes of between of 0.6°C to 1.15°C (emissions stabilising before 2100), and 0.75°C to 1.5°C (high-emissions scenario) (Wood & Moriniere, 2013). The assessment also projects that, for the period 2040-2060, the early summer months of October and November will be warmer, with an increase of between 1.75°C to 2.5°C (Wood & Moriniere, 2013). Rainfall projections are not consistent across models and thus do not indicate substantial changes in annual rainfall, although some studies suggest a possibility that rainy seasons will grow shorter, which would lead to recurring droughts (Irish Aid, 2017).

Key sectoral contributors to climate change in Malawi

GHG emissions are the cause of climate change. The AR5 highlights that anthropogenic GHG emissions have increased since the pre-industrial era, driven largely by economic and population growth, and are now higher than ever. The report further states that it is the effect of these gases in the atmosphere that has been the dominant cause of global warming since the mid-20th century. Globally, energy sector activities are the greatest source of GHG emissions (49%), driving climate change. These emissions come from burning fuels to heat and light buildings, cook food, and power motor vehicles and aeroplanes (Malawi, 2019). At the global level, the mining sector is extremely energy-intensive and, therefore, one of the major emitters of GHGs.

Historically, developing countries like Malawi have not made a significant contribution to the emissions currently causing the climate crisis. As a least developed country (LDC), Malawi is not obliged to reduce its levels of GHG emissions at the expense of its emerging economic growth and development (Malawi, 2011). Emissions in Malawi have steadily grown, increasing 35 percent over the seven-year period from 2010 to 2017 (Malawi, 2017). In its second national communication, Malawi was classified as a net emitter of CO_2, with the highest contributions coming from the following three sectors: forestry, land-use change and energy (Malawi, 2011). In Table 5.1, it is projected that the emissions from the sectors will continue to be the leading contributors.

Table 5.1: Baseline scenario projections by sector in Giga grams for 2015-2020. *(**Source**: Malawi Nationally Appropriate Mitigation Actions (NAMA, 2015)).*

SECTOR	2015	2020	2025	2030
Energy	795.38	4,782.20	4,961.10	5,140.00
IPPU	72.04	78.17	84.30	90.43
AFOLU: Agric.	8,990.58	9,418.44	9,846.30	10,274.16
FOLU	16,935.80	17,741.40	18,547.00	19,352.60
Waste	472.43	531.63	590.83	650.03
TOTAL	27,266.23	32,551.84	34,029.53	35,507.22

For the purposes of this study, the analysis of climate change impacts and response in Malawi will be limited to two key emission sectors, energy and land-use change and forestry, in accordance with the IPCC guidelines on emission-accounting under Malawi's GHG-Inventory System (Malawi, 2019). The following section will now look at the two categories and their relationship with the extractives sector in Malawi (for the purposes of this study, waste has not been included, and industry has been considered within energy).

Energy

The energy sector plays an important role in the socio-economic growth and development of the country. It is the backbone of the mining and manufacturing industries, power generation, agriculture production, transportation and various industrial and domestic enterprises. Through these activities, the sector contributes significantly to GHG emissions, mostly through the combustion of liquid and solid fossil fuels, biomass and fugitive emissions. Over the last two centuries, the growth of fossil-fuel combustion has been closely coupled to the global growth in energy use and economic activity. Fossil-fuel emissions grew by an annual 3.2 percent from 2000 to 2010 (Malawi, 2019).

Land-use change and forestry

Since the pre-industrial period, changes in land cover due to human activities have led to both a net release of CO_2, contributing to global warming (high confidence), and an increase in global land, causing surface cooling (medium confidence) (IPCC, 2018). The likelihood, intensity and duration of many extreme events can be significantly modified by changes in land conditions, including heat-related events, such as heatwaves (high confidence), and heavy precipitation events (medium confidence) (IPCC, 2018).

In the Initial National Communication of Malawi to the IPCC, the 1994 and 1990 GHG inventories conclusively stated Malawi as a net emitter of CO_2, with the greatest contribution of emissions arising from the land-use change and forestry (LUCF) sector, followed by the energy sector. The conversion of forests to other land uses accounts for approximately 10 percent of global carbon emissions (IPCC, 2018). Malawi used to have the largest man-made forest in Southern Africa, originally called Chikangawa Forest. However, the country's forests have been depleted unsustainably due to the heavy reliance on the forests and forest resources as a source of energy and illegal logging.

Malawi's national climate change policy framework and extractive industries

The Government of Malawi (GoM) has made efforts to develop policy frameworks for ensuring a climate-resilient development pathway. Specifically, Malawi's medium- and long-term development strategy, the Malawi Growth and Development Strategy (MGDS) III, identifies agriculture and climate change as a key priority area. The strategy seeks to achieve sustainable agricultural transformation and water development that is adaptive to climate change and enhances ecosystem services.

At the same time, the MGDS provides for increasing exploration and the mining of mineral resources and projects a 20 percent contribution of the mining sector to the national GDP by 2022. The government has also made efforts to develop various frameworks and operational instruments for managing climate change. These include the National Adaptation Programmes of Action (NAPA) of 2006, which was revised in 2015. This plan identifies urgent and priority areas of adaptation interventions. At the same time, Malawi embarked on the National Adaptation Plan (NAP) process which builds on the NAPA but focuses on medium to long-term adaptation needs.

The adaptation needs addressed by the NAPA are in agriculture, health, energy, forestry, fisheries, wildlife, gender, water and infrastructure. These nine sectors are explicitly mentioned as priority sectors that required urgent adaptation interventions.

While there is no specific mention of the extractives sector, the inclusion of the energy sector as a priority has a significant bearing due to the high energy demand and generative contribution of extractive industries. The current electricity generation capacity is only 351 MW, against an estimated suppressed demand of 400 MW (Malawi, 2015b). According to Malawi's Intended Nationally Determined Contribution, the national electricity generation deficit is not only a hindrance to new investments in mining and other industries, but it is also detrimental to the social and economic wellbeing of its people. The projected increase of the contribution of the mining sector to the national GDP implies increased energy demand for the sector.

It should also be noted that Malawi adopted a National Energy Policy in 2018. The policy recognises the negative impact of climate change on the generation and supply capacity of electricity in the country, which is heavily reliant on hydro-generation (Malawi, 2018). Accordingly, the extent to which the mining sector could contribute to mitigation efforts, as committed under Malawi's Intended Nationally Determined Contribution (INDC) and which would have adaptation co-benefits, largely depends on the energy options that the industry will be willing to adopt. This is especially significant as the country explores options to supplement power generation, such as use of coal.

Malawi also has a National Resilience Strategy, which aims at eradicating chronic vulnerability, and food and nutrition insecurity. It aims to achieve a situation where sustainable economic development creates opportunities for everyone, and where people are resilient to economic and environmental shocks that affect their lives and livelihoods. The strategy has four pillars, namely resilient agriculture, reduced exposure to hazards and early-warning response, social protection and natural-resource management. The strategy, with the theme "Breaking the Cycle of Food Insecurity in Malawi", was developed largely as a response to climate impacts on food production in an agro-based economy, hence the absence of mining-specific adaptation or mitigation options in the strategy.

A more overarching policy framework is the National Climate Change Management Policy of 2016 (Malawi, 2016). The policy's overall goal is to promote climate change adaptation, mitigation, technology transfer and capacity building for sustainable livelihoods through green economy measures for Malawi. The policy's implementation plan provides strategies for adaptation in agriculture, water, health, human settlements, energy, forestry, biodiversity and fisheries. At the same time, the framework provides for mitigation actions in land use (forestry and agriculture), renewable energy technologies (energy-saving and low-carbon technologies, and biofuels), reduced emissions from deforestation and degradation, clean development mechanisms and payment for ecosystem services. It is noted that the mining sector is not directly included as a target for adaptation and mitigation strategies in the policy.

Despite the various national initiatives on climate adaptation and mitigation, there remains a clear gap for interventions and responses targeting the extractive sector in the country. Overall, most of the initiatives have been aligned with the agriculture and energy sectors. While the extractive sector partially fits within the energy sector, the lack of its separation from the broader discussion has limited the exploitation of its potential to contribute to climate adaptation and mitigation efforts.

In the national Climate Change Response Plan (CCRP), the government identifies the limited role of the private sector, which includes the extractive sector as one of the limitations in the existing national climate-management framework. The National Climate Change Policy also provides further scope for the involvement of the private sector as follows:

> *The private sector is an important stakeholder when it comes to economic growth and job creation in the country and therefore must play an active role in climate change management. The private sector is critical in achieving a low carbon emission development for Malawi through investing in cleaner technologies and provision of green jobs. Government can provide incentives for this and promote public-private partnerships to take this forward. Furthermore, the private sector should take an active part in decision making on climate change initiatives. This can be achieved through representation in the NTCCC through the Malawi Confederation of Chambers of Commerce and Industry (MCCCI) as a platform for providing their input and participating in climate change management in the country. In particular, the private sector can take an active role in participating in projects for carbon emissions trading including Clean Development Mechanism (CDM), low carbon development, offsetting their emissions and investing in renewable energy. (Malawi, 2016)*

The range of mitigation and adaptation actions that can be deployed within the sector in the short run are well-known. For example, there are the following actions:

low-emission technologies, new infrastructure and energy efficiency measures in infrastructure and transport; sustainable land and water management, ecosystem restoration, enhancement of adaptive capacities to climate risks and impact, disaster risk management, research and development; and, the mobilisation of new, traditional and indigenous knowledge (IPCC, 2019; Crawford, 2019; Odell et al., 2018; Malawi, 2016). However, there is a need for a concerted effort to bring these into policies and climate change planning platforms to address the challenges and abilities of the extractive sector.

Mitigation and adaptation are complementary approaches for reducing the risks of climate change impact over different timescales (IPCC, 2019). Mitigation, in the short term and through the century, can substantially reduce climate change impacts in the later decades of the 21st century and beyond (IPCC, 2014). Benefits from adaptation can already be realised in addressing current risks and can be realised in the future for addressing emerging risks. There are multiple opportunities for companies to manage climate risks through investments in climate-resilient infrastructure, consideration of climate impacts in procurement decisions, integrating climate change into business plans and climate proofing supply chains (IPCC, 2014).

According to the 2014 Synthesis report, there is medium evidence and high agreement that climate services can play a critical role in aiding adaptation decision-making (Vaughan & Dessai, 2014; IPCCC, 2014). The International Institute for Sustainable Development (IISD) supports that one of the ways in which governments can support mining companies in climate change management is through the generation and sharing of climate change information (Crawford & Church, 2019). However, this can also be supported by mining companies who can equally play a role in the generation of climate information to increase the resilience of mining-affected communities through increased access to accurate and relevant climate information. While there is currently no record of this happening in any of the mining sites in the country, it is worth learning from similar practices in other sectors, which can be adopted in the extractive sector as is shown in Case 1.

CASE STUDY 1: ENHANCING RESILIENCE THROUGH WEATHER AND CLIMATE INFORMATION

In Malawi, the generation and accessibility of climate information is one of the key measures being adopted to help smallholder farmers in risk preparedness where the sector continues to be increasingly affected by climate shocks. In the National 2013 Vulnerability Assessment report, one of the technological barriers contributing to increased climate vulnerability is that "meteorological and climatological indicators are not being monitored with sufficient geographical coverage, sampling frequency and rigor, nor are the relevant data being maintained in a readily accessible form" Wood & Moriniere, 2013). Effective climate-resilience planning can only be achieved with climate information on current and future climatic trends.

In 2017, the Government of Malawi, through the Department of Disaster Management Affairs (DoDMA), with support from the United Nations Development Programme (UNDP), launched a project to scale-up the use of modernised early-warning systems and climate information across 21 of the country's 28 districts. The project is called "Saving Lives and Protecting Agriculture-based Livelihoods in Malawi: Scaling Up the Use of Modernised Climate Information and Early Warning Systems (M-CLIMES)" (UNDP, 2017).

Fig 5.1. A picture of a mini-meteorological station at the Songwe Hill Mkango Site in Phalombe, Malawi *(Picture by Gloria M. Kamoto).*

As one of the options for adaptation in the extractives sector, the M-CLIMES project provides a model on how government and companies can work together to facilitate risk preparedness for companies, government and mining-affected communities.

In Songwe Hill, where Mkango Resources Limited is conducting the exploration of rare earth minerals, a mini-meteorological station with advanced technology functions to facilitate the generation of data to inform the development of the company's environmental social-impact assessment (ESIA).

As a climate-shock-prone area, the station site, Phalombe, has experienced extreme weather events, such as heavy rainfalls, floods and dry spells, thus increasing the vulnerability of the local communities. Climate data is an essential input for the development of technologies and innovations for adaptation and mitigation for companies, communities and national governments. In order to minimise the potential negative impacts of the mining project on the vulnerability of the community and learning from the M-CLIMES project, the company has the potential to contribute to the preparedness and climate resilience of mining-affected communities by supporting the generation of accurate and relevant climate and weather information.

Another aspect to the adaptation function can be exploited through project climate risk assessments, which can be used for climate proofing at different levels. Currently, the legal framework in Malawi requires most extractive related projects to conduct an environmental social-impact assessment. However, from the experience of Kayelekera Mine, it is clear that the assessments do not provide enough scope to account for the anticipated climate and weather shocks that would affect the parameters of the ESIA. In the same way the ESIA results in environmental social management plans (ESMP), the process of climate risk assessment or vulnerability assessment would result in the development of actions that facilitate the protection of the project and communities from the negative impacts of climate change, climate variability and extreme weather events.

In the climate risk management and adaptation strategy proposed by the African Development Bank, the group proposes that the climate proofing of investments would help to ensure that climate-friendly development strategies are pursued to delay and reduce damages caused by climate change (AfDB. 2009). While the proposal was made primarily to protect the interests of the group's investment, the approach provides an entry point for mining companies to participate in national climate management planning processes since they will have adequate information about their anticipated impacts on the climate vulnerability of the country and host communities as well as the anticipated impacts of climate change on their project. This can mobilise the appropriate support for adaptation interventions and mitigation actions, such as subsidies, green bonds and disaster-preparedness funding.

Regional policy levers for Malawi to advance climate mitigation and adaptation policy efforts

There are various incentives and disincentives for adaptation and mitigation for governments and companies at global and regional levels. At a global level, the commitment towards zero net emissions to maintain the temperature between 1.5°C and 2°C is the biggest driver for Malawi and mining companies to engage in climate mitigation and has continued to shape national climate change policies. Following the increasing climate shocks and disasters experienced over the last few years, Malawi has first-hand experience of the devastating impacts of climate change on the economy and now continues to take an increasing interest in mitigation efforts to increase national resilience. There is increasing awareness at the governance level of the magnitude of the climate crisis and the need to expedite adaptation in order to continue on the desired path of development.

The global shift towards a low-carbon economy has also led to the development of international policies, such as the European Union Green Deal, which can further incentivise mitigation for governments and companies by disrupting the supply chains for carbon products like coal, oil and gas. Oil- and gas-company partners also continue to face growing pressure to reduce their upstream emissions and make the transition to a 'Paris-aligned' business model (Bradley, 2020). These trends make it increasingly difficult to mobilise financing for carbon-based investments, such as coal, as has been reiterated by both government and private-sector stakeholders in Malawi, and possibly contribute to the increased ease of access to mitigation and adaptation technologies.

At a regional level, climate change has heightened the urgency of the need for regional integration to buffer the impacts of climate change, which transcends the borders. The SADC trade protocol provides an incentive for mitigation actions and technology developments through its support for the development of cross-border infrastructure, food security or protection of natural resources (Qualmann, 2000). In addition, the SADC Regional Energy Access and Action Plan and the SADC Regional Infrastructure Development Master Plan provide new opportunities for increased access to energy, which may significantly lower the cost of mitigation and adaptation for governments and companies. While Malawi may not have the full capacity to support mitigation, such frameworks create an opportunity for cross border collaboration, thus lowering the cost of mitigation while increasing access to energy for sustained development.

At the national level, Malawi's climate change management and response policy framework is currently shaped by its INDC, which was developed in response to the decisions adopted at the 19^{th} and 20^{th} sessions of the COPs to the UNFCCC In the INDC, Malawi recognises the urgent need to build the resilience of productive sectors to the associated negative impacts of climate change. While the INDC highlights that it is premised on the sectors that can make the greatest contribution to GHG-abatement and resilience-building, it also gives scope for the consideration of emerging issues in other key sectors, in this case the extractive sector. In order to achieve its targets, the government has made some significant commitments, such as the diversification of power generation sources, which includes supporting private-sector investment in power generation and for which the government has already been scoping for the establishment of public-private partnerships (PPPs) in the energy sector. There have recently been developments in the electricity transmission network, which brings an incentive for the integration of independent power producers (IPPs) or PPPs, and interconnection prospects with Mozambique and Zambia, which are now in the pipeline (Malawi, 2018).

In addition to this, Malawi's huge potential for renewable energy is a good incentive for investors willing to take advantage of the enabling policy framework on energy. The total installed generation capacity for the country is 361 MW, 91 percent of which comes from hydropower plants located on the Shire and Wovwe Rivers, and the remaining 9 percent comes from standby diesel or petrol generators (Malawi, 2018). In its intended policy-based actions in the INDC, the country made significant commitments to mitigation actions towards reducing GHG emissions, which can create an incentive for government and companies to innovate and effectively manage climate change impacts.

The most distinct barrier and disincentive to climate mitigation and adaptation in the extractive sector are the competing interests between national development and the climate agenda. One of the commonly shared sentiments among respondents in this study was the need to prioritise national development for a country like Malawi, which has not been a huge contributor to the climate crisis and therefore does not deserve to suffer economic regression. Stakeholders expressed the view that developed countries have the luxury to cut back on hydrocarbons because they have the financing for alternatives. This is not peculiar to Malawi and has often been reiterated by African countries, which are looking forward to growing their economies through natural-resource extraction and resource-dependent countries which heavily rely on the carbon industry. One respondent indicated that Malawi will still need to use coal and other fossil fuels to generate the base load needed to drive the country to an acceptable level of economic development.

Another disincentive is that of national interests versus regional interests, which has affected the level of coordination in mitigation and adaptation efforts between countries, whereby the priority is on national over regional development. In addition, the high cost of mitigation technologies is also a disincentive for climate mitigation in underdeveloped countries, such as Malawi.

Climate change and its impact on Malawi's extractive sector

Mining in itself is a source of new challenges for the extractive sector and environmental management because its activities directly impact climate change. Mining activities contribute to land-use change emissions due to the clearing of vegetation cover, which induces deforestation and reduces the available sinks for carbon. Mining also causes dust pollution, leading to an increase in the amount of aerosols in the atmosphere and this may enhance the trapping of GHGs (Malawi, 2002). This sub-section further examines the relationship between climate change and the mining sector to appreciate the experiences and the prospects of the industry in a changing climate.

The relationship between extractives and climate change has continued to gain much attention over the last few years, especially as the world is under increasing pressure to meet the zero net emissions in line with the current carbon budget. While there is relatively limited knowledge of the direct impact of climate change on the mining sector, most existing research agrees that changing climatic conditions will have both direct (operational and performance-based) and indirect (securing of supplies and rising energy costs) impacts on the mining sector (Sharma et al., 2013; Rüttinger & Sharma, 2016).

In their review and analysis of the relationship between mining and climate change, Odell et al. explore a potent framework that can be used for further analysis and generation of knowledge in the sector (Odell, Bebbington & Frey, 2018;). The framework highlights five relationships that can be used as a lens to examine the nexus between climate change and extractives. The first relationship states that, "Climate change affects mining". The study offers the following two ways in which climate change affects mining: a) mining operations are vulnerable to climate change; and, b) climate change could open new areas to mining.

In assessing the impact of climate change to the extractive sector in Malawi, this study adopted the two parameters offered by Odell within the effectual relationship between climate change and mining.

1. *Vulnerability of mining operations' infrastructure and surrounding communities:* Although the mining sector in Malawi is still in its infancy, there was evidence that it has so far been prone to the impacts of climate change. In the case of the Kayelekera Uranium Mine (KM) in case study 2, there is a clear confirmation of the argument in Odell's analysis, which considers that climate changes could increase the likelihood of spontaneous mass movement of rock material (such as landslides), which can be triggered by weather events. Most available studies noted that mining sites are often built with a steady climate in mind and do not often take into consideration the possible climate shocks that would have an impact on their infrastructure and operations.

CASE STUDY 2: RAINFALL, PREPAREDNESS AND THE KAYELEKERA URANIUM MINE POND OVERFLOWS

The Kayelekera uranium deposit is located in northern Malawi, 52 km west (by road) of Karonga, a town on the western shores of Lake Malawi located 573 km from the capital city of Lilongwe. Kayelekera was the first major mining venture in Malawi and considerably contributed to the GDP, with about 1 percent during its operational period and had an average production of 1,500 tonnes per year. The mine is currently under care and maintenance in the hope of a shift in the global demand for uranium in the coming years.

In 2015, Malawi experienced heavy rainfalls, which led to flooding across the country, resulting in damages estimated at MWK124.5 billion (USD 286.3 million) and losses amounting to MWK21 billion (USD 48.4 million) (Malawi, 2015a). In January 2015, various reports came in on the damage that the heavy rainfall had caused at the uranium mine. In one of the news reports, it was stated that:

> *The resultant surge of stormwater caused the liner in the plant run-off tank to rupture, releasing up to 500 m3 of material to the bunded areas of the site. Up to 0.05 m3 (50 litres) may have overtopped one of the containment bunds due to the nature of the rainfall event at the time. (Sidler, 2015)*

Climate change has increased the pressure on natural resources, including water. The continued spillages from the mine increase the vulnerability of the host communities, since they risk losing easy access to water resources. During the occurrence of the spillages, the communities were advised to refrain from using the water bodies despite not being provided with alternative sources of water supply. No strict controls were enforced to keep people from using these resources in the immediate impact area and downstream. This competition over natural resources is a typical characteristic of the relationship between climate change and the extractive sector as an accelerant to vulnerability.

In their review of the Kayelekera Uranium Mine Project Environmental Social-Impact Assessment, Mudd and Smith note that the assessment lacked updated climate data, which would have been relevant to determining the quality of the structures to be constructed, such as the tailing dams and an overall lack of a strong commitment to completely prevent discharge of contaminated mine-site water during extreme weather events, as a major concern (Mudd and Smith, 2006).

A few years after the project was commissioned, the assessment findings were affirmed by the spillage of a tailings dam due to unusually heavy rains in the area. More than three spillages later (see Case 2), it is clear that the integrity of KM structures to weather shocks such as heavy rainfall has failed to pass the test and has possibly put the lives of surrounding communities at risk and increased vulnerability. While the company has insisted that there has been no contamination; this has not yet been verified by any openly accessible studies on the water quality and so the actual damage remains unknown.

A CSO working in the area, shared the experience of the communities living around the Sere River (the river was affected by the spillage). The communities had no other sources of potable water, such as boreholes. This means that they were left with no alternative, but to continue using the water that may or may not have been contaminated. Not only are climate-induced organisational and operational risks for mining activities important in and of themselves, but the associated reputational risks to the organisation and its social licence to operate may be fatally permanent in nature (Rüttinger & Sharma, 2016). The KM presents a good example of how climate change-induced (mis)management of mining impacts may exacerbate tensions with host communities and breed the potential for conflict due to increased climate change vulnerability from the presence of the mine.

With regard to the operational and performance-based impacts, there is conclusive evidence of significant damage and losses incurred by the industry and trade sector during extreme weather events (Malawi, 2015a). Following the 2015 floods, Malawi reported the disruption of business operations, destruction of industry and public infrastructure (relevant to business, such as roads), disruption of power supply, limited access to raw materials and disruption of supply chains (Malawi, 2015a). While there was no readily available data on the specific impacts of the floods on the mining sector, the implications of the disruption to the industry do apply to the mining sector as well, which mostly relies on export marketing and imported supplies.

2. *New mining opportunities due to climate change:* In order to achieve the climate change goals in the Paris Agreement, the extractive sector will have to change its focus to new types of minerals, which are low carbon and positively contribute to the global climate goals. A low-carbon future is expected to be very mineral-intensive because clean-energy technologies need more materials than fossil-fuel-based electricity-generation technologies. Greater ambition on climate change goals (1.5°C–2°C or below), as outlined by the Paris Agreement, requires installing more of these technologies and will therefore lead to a larger material footprint (Hund et al., 2020). For Malawi, this presents both an opportunity and a risk of increased climate vulnerability.

On the one hand, as a new mining economy, Malawi is not classified as a resource-rich or resource-dependent country. However, the country has demonstrated a potential for deposits of carbon minerals, such as coal, oil, gas and transition minerals such as rare-earth minerals and graphite. In his analysis, Malunga confirms the presence of rare-earth mineral deposits at Kangankunde, Tundulu, Songwe and Chilwa Island (Malunga, 2016). The World Bank classifies graphite as a high-impact mineral, which is expected to have a much higher demand due to its predominance in energy-storage technologies, while rare-earth minerals are classified differently. The latter minerals are acknowledged for their critical role in the production of a wide variety of energy technologies (Malunga, 2016). This means that prioritising the extraction of transition minerals, which are increasingly in demand, has the potential to boost economic development for Malawi currently with 14 exploration licences related to rare earth and graphite (Malawi Ministry of Mining, 2021).

On other hand, tightening climate policies, fossil-fuel investment and renewable energy (RE) trends suggest that the cost curves for commercially viable oil and gas projects are changing, and that the time frame for profitable production will be limited (Odell, Bebbington & Frey, 2018). The international commitment to limit global warming to well below 2°C above pre-industrial levels – and as close as possible to 1.5°C – means that fossil fuel use must fall dramatically over the next 30 years. Previous research estimated that, under such a 2°C carbon budget, 80 percent of coal, 50 percent of oil and 33 percent of gas reserves would be ‘unburnable’. Malawi currently has 12 coal mining and exploration licences covering approximately 240.5248 km^2 and 6 oil exploration areas, which align with the national energy and economic development aspirations as contained in Case 3.

CASE STUDY 3: A FOSSIL FUELLED BOOST FOR MALAWI

Over the last few years, Malawi has looked towards the diversification of the economy through the extractive sector. Specifically, the country is exploring the potential for oil production. In 2009, the country demarcated six oil-prospecting areas or blocks and has since proceeded to award prospecting licences for the blocks. The potential for oil and gas discovery in Malawi is very high, especially in Blocks 2 (Karonga), 3 (Nkhata Bay, Nkhotakota) and 6 (Chikwawa, Nsanje). Blocks 1 (Chitipa) and 5 (Phalombe) have relatively shallow sediments of up to about 3,700 metres.

One of the driving factors for the country is the potential to use profits from the oil to start a fund to invest in the country and bring it prosperity. For an agro-based economy relying mostly on rain-fed agriculture, diversifying into oil production offers the potential for increasing the national capacity to adapt to the impact of climate change. However, in the wake of climate change and a very small global carbon budget, countries like Malawi risk a write-off of potential gains from their precious resources before a cash out. Despite the financial and socio-environmental risks, Malawi continues with exploration of carbon resources in the hope of a carbon-fuelled development boost. As echoed across the country and beyond the continent, it is clear that leaving its carbon resources in the ground is not an option for Malawi.

The scenario in the case study presents two key challenges. First, the new mineral demands set on by decarbonisation could result in "stranded assets" should the country continue on the current production trajectory and fail to respond to global demand shifts. ("Stranded assets" are assets that become devalued before the end of their economic lifetime or can no longer be monetised due to changes in policy and regulatory frameworks, market forces, societal or environmental conditions, disruptive innovation or security issues.) (UNU-INRA, 2019). Malawi has already previously experienced this with the stranding of its uranium resources due to the decline in international commodity prices, which had initially pegged the mining sector GDP contribution at 20 percent but is now only contributing 0.8 percent. As the country continues to bank on securing foreign direct investment (FDI) into its fossil fuel sectors, there is a need to have a good understanding of the ways in which different actors are responding to evolving uncertainties and risks, and how this is re-shaping global investment patterns and plan strategically (UNU-INRA, 2019).

Second, because of the material intensity of low-carbon technologies, any potential shortages in mineral supply could have an impact on the speed and scale at which certain technologies may be deployed globally (World Bank Group, 2017). This means that low-carbon technologies will either be in short supply or too costly for a developing country like Malawi, thereby limiting the availability of energy to fuel a development boost. This can also potentially widen the inequality gap between developed and developing countries, further increasing vulnerability of the latter.

Options for mitigation and adaptation actions

An effective response to climate change in the context of a developing country such as Malawi requires financial, technological and other forms of support to build capacity for which additional local, national and international resources would need to be mobilised (Crawford, 2019. Malawi is still interested in developing hydrocarbon deposits in the country to expedite economic development as evidenced from the various permits granted on coal, and oil and gas exploration, and the energy source projections that still include a considerable percentage of fossil-fuel sources. Regarding the likelihood of poor countries continuing to use hydrocarbons to fuel economic growth, Professor Sachs appreciates that "… eventually, all countries will need to decarbonize comprehensively, but it is probably sound to allow the poorest countries, notably in Africa, to continue to use their local fossil fuel resources for longer than is the case in the middle-income and high-income countries" (Sachs, 2016).

The question now lies in exploring how government and companies can work together to enhance benefits from the mining sector while managing the associated climate risks and vulnerability. Adapting from the IIED recommendations in key areas of action for government intervention, the study presents the following proposed options for action (Sachs, 2016):

1. *Undertake climate proofing in development planning – Climate Proofing for Development is a methodological approach aimed at incorporating issues of climate change into development planning (Hahn, 2010). In order to address the existing, disconnect between the planning a*gencies and stakeholders, the idea of climate proofing presents a wholesome approach to the mobilisation of relevant stakeholders and resources for enhanced climate response and resilience. As a starting point, the government should embed pillars such as:

- Climate risk and vulnerability assessment;
- Climate response plans into all levels of development;
- Multi-stakeholder engagement in platforms such as the NAP process and its Nationally Appropriate Mitigation Actions (NAMAs).

Regulatory instruments such as the ESIA guidelines can be revised to facilitate climate management processes at project, community and national levels. This also means that mining companies will be able to better understand their role in the national climate management processes and decrease their own vulnerability to climate change risks.

2. *Investment in research and development* – Malawi should invest in innovative research and development to increase capacity in climate management. In order to address the knowledge limitations on climate change and extractives, the government and companies need to work together to generate knowledge that can inform appropriate technologies for adaptation and mitigation to specific contexts. Some information of relevance would be the types of minerals, appropriate mining technologies that would not exacerbate climate vulnerability, and emerging issues in the sector. The government needs to learn from the stranded uranium deposits and avoid confinement to the fossil-fuel-driven development pathways, which are extremely vulnerable to market volatility. It is, therefore, imperative that Malawi generates relevant geographical data to strategically position itself in a changing global landscape.
3. *Remove financial barriers to climate management* – In order to address the financial barriers for adaptation and mitigation, the government should develop policies and laws that encourage and support investments in mitigation and adaptation within the mining sector, including through the licensing process. It should also financially incentivise climate management and response through progressive tools like tax exemptions on low-emission technologies, green bonds and the creation of co-funding facilities for climate progressive technologies and projects. This also means that the true costs of carbon emissions should be captured through appropriate taxing regimes imposed on contributing resources such as coal. To ensure that the resources are maximised for resilience building during the transition through mitigation

and adaptation technologies, the Malawi Extractive Industries Transparency Initiative can serve as a useful tool in capturing and generating relevant climate data through climate disclosures under the environment and social reporting requirements.

Conclusion

As the world shifts further towards zero emissions, Malawi is at a crossroad. Like many other resource-dependent countries, the global shift from fossil fuels presents a wicked problem for the country, which needs to build its resilience through a resource base that can be mobilised through revenues to be largely generated from fossil fuels. As the country ponders on the exploration of its hydrocarbon deposits and the possibility of coal to meet its national energy needs, the question that comes to mind is whether this pathway will leave the country better off or worse off. On the one hand, a constant fossil fuel production rate requires increasing energy input, but also use of more land, water and diluents, with the production of more waste, which are all high-emission contributors and are becoming conflict points between companies and vulnerable communities. This means that a bigger investment in a carbon-based economy could leave the country worse off and lead to stranded assets. On the other hand, the strategic mining of minerals relevant to the transition could provide the economic growth needed for the country to access relevant technologies and resources to set it on a more sustainable development path and increased resilience.

The global energy transition has brought into question the role of the extractive sector in a decarbonised world. It is therefore crucial that Malawi becomes better positioned to decide how to take advantage of the future commodities market responding to climate and related SDGs, promoting affordable and clean energy (World Bank Group, 2017). The government needs to work with investors to facilitate appropriate responses to climate challenges by reducing their GHG emissions and contributing to local efforts to mitigate climate change through knowledge generation and community-based interventions. The increased understanding of the nexus between climate change and extractives presents an important departure point in exploring the opportunities for the co-existence of the extractive sector with humanity in a decarbonised world.

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6
Exploring Legal Tools for Mainstreaming Climate Change in the Extractive Industry

Amanda Mugadza

Abstract

The Southern African region currently faces serious challenges with respect to addressing climate change in the extractive industries. This adversely affects the region's broader sustainable development agenda. This study explores the mainstreaming of climate change in the extractive industry of SADC member states from a legal perspective. It is premised on the understanding that the region's sustainable development agenda may only be achieved through the mainstreaming of climate change. To this end, a normative framework that incorporates mechanisms for climate action into the extractive industry is a necessary condition for the mainstreaming processes. It examines the life cycle of the mining project to establish how mining typically influences and is influenced by climate change, thus contextualising the need for mainstreaming climate change in the industry. Climate change itself negatively affects key activities and processes in mining and thus requires legal tools to ensure that the industry adapts to climate change. The study assesses the progress of Botswana, South Africa and Zimbabwe, which have normative frameworks that promote the mainstreaming of climate change in mining. It concludes that, in the absence of specific climate change legislation, it is not enough to have indirect legislation and tools, as these do not facilitate the mainstreaming of climate action. This study recommends that SADC countries should have specific laws and tools that address climate change in the industry to facilitate the mainstreaming processes.

Introduction

The challenges facing the Southern African region with respect to climate change and the extractive industries indicate that climate change action is still in its infancy, especially where law and policy are concerned. Despite participating in international climate change conferences, the domestic normative frameworks for the extractive industry in most of the SADC member states fall short. The effect of this gap in law and policy, in the region's climate change responses, and particularly in the extractives industry, exposes and weakens all efforts towards the broader sustainable development agenda. It is necessary, therefore, to consider mainstreaming climate change in SADC member states' extractive industry for sustainable development.

One of the facets of this mainstreaming involves developing a normative framework that incorporates mechanisms for climate action. This study explores the necessary legal tools in this framework, with a focus on the environmental governance-based tools approach. The approach considers the traditional command and control tools, incentive-based tools, agreement-based tools, civil-based tools and how these can be employed in developing the necessary regulatory framework for mainstreaming climate change in mining.

Discussion in this paper commences with the specific legal principles of sustainable development that influence the climate change regime. It is the application of these principles in the extractive industry legal regime that necessitates the mainstreaming of climate change. The study considers the project life cycle of a mine to establish how such life typically influences and is influenced by climate change. To build an effective and holistic legal response through mainstreaming climate change, the study then considers the role of the various actors in the industry and the tools they require to facilitate this mainstreaming. In the final analysis, the study explores the value of these legal tools by examining the legal frameworks on climate change and mining of selected SADC participating countries, namely Botswana, South Africa and Zimbabwe.

Sustainable development in legal discourse

Sustainable development is based on the understanding that economic development in any given setting must focus not only on the economic benefits to be realised, but also on reducing poverty and improving the welfare and security of the poor, while protecting natural resources and ecosystems from irreparable damage and overexploitation. This observation was contained in the following initiatives: United Nations General Assembly (UNGA) Resolution of 1962 (17th Session); the United Nations Conference on the Human Environment (UNCHE) held in Stockholm in 1972, and which led to the *United Nations Declaration on the Human Environment* of 1972; the *World Charter for Nature* of 1982; and, the Brundtland Report of the World Commission on the Environment and Development (WCED) of 1987, titled *Our Common Future* (Brundtland Commission, 1987). Then there was the United Nations Conference on the Environment and Development (UNCED) in Rio de Janeiro in 1992 in its subsequent Declaration, Agenda 21, and the World Summit for Sustainable Development (WSSD) in Johannesburg in 2002, successive Rio + conferences, and the United Nations Sustainable Development Summit of 2015.

In sustainable development law, the legal principles governing sustainability derive from the intersection between international economic law, international environmental law and international social law (including human rights law) (Barnard, 2012; Virginie Barral, 2012; Owosuyi, 2015; Fitzmaurice, 2010; Cordonier Segger, 2004; Kenig-Witkowska, 2017; Majid, Latif & Koe, 2017; Mekonin, 2013, p. 12-16; Göpel, 2010). These principles are consolidated in the *New Delhi Declaration of Principles of International Law Relating to Sustainable Development.* The declaration is a resolution of the 70th Conference of International Law Association (ILA) held in New Delhi, India, in 2002 and is a non-binding instrument prepared by ILA, which consolidates the principles of international law relevant to the activities of all actors involved in pursuing the objective of sustainable development (ILA, 2002). Although the principles in this declaration emanate from international law, they serve as an ideal norm that is universal, but also flexible enough to guide laws and policies at regional, national and local levels (Göpel, 2010). These principles of sustainable development have significantly influenced the development of the climate change regime.

The relationship between sustainable development and climate change law

The climate change legal regime regulates the human activities that accelerate climate change and protects the climate system for present and future generations (UN, 1992). At the international level, this regime is governed by the UNFCCC of 1992 established on the same platform that introduced sustainable development into the international legal discourse. This is important in understanding the nature of climate action and the legal principles that form its bedrock. This position is consistently carried through in subsequent binding instruments including the Kyoto Protocol of 1997 and the Paris Agreement of 2015. These instruments recognise that the steps required to understand and address climate change should be environmentally, socially and economically effective as well as economically justifiable to help solve environmental problems (UN, 1992; 2015, Preamble). In effect, there is the principle of sustainable use of the natural resources by states within their territories, which demands that there should be a proper management of the climate system, including biological diversity and wildlife (ILA, 2002; UN, 2002, Preamble). This calls for mitigation measures and policies that are integrated with NDCs to protect the climate system against human-induced change (UN, 2002, Article 3(4)). To this end, states should develop nationally determined contributions (NDCs), to achieve the global goal of holding the increase in global average temperatures to well below 2°C above pre-industrial levels UN, 2015, Article 2(1) & 3).

At a national level, addressing climate change and its adverse effects calls for nationally appropriate mitigation actions (NAMAs) to reduce the anthropogenic emissions by "sources" of GHGs across sectors and within sectors (UN, 1992, Article 4(1)(b)). UNFCCC defines sources as all processes or activities that release GHGs into the atmosphere. Sectoral approaches are described in the Bali Action Plan (UN, 2007, para 1(b)(v)), the UNFCCC (UN, 1992, Article 4(8)) and the Paris Agreement (UN, 2015, Articles 6(8), 11). These include the sustainable management, conservation and enhancement of GHG "sinks" and "reservoirs" such as biomass, forests, oceans and other terrestrial, coastal and marine ecosystems. For instance, reducing emissions from deforestation and forest degradation (REDD) mechanisms and maintaining and conserving forest carbon stocks are important. In addition, governments should promote the development, application and financing of environmentally sound technologies, practices and processes that control, reduce or prevent anthropogenic emissions of GHGs in all relevant economic sectors, including the extraction industry (UN, 1992, Article 4(1)(b); UN, 2015, Article 10). Tools such as environmental impact assessments (EIAs) are also crucial to minimise the adverse effects of their mitigation measures on the quality of the environment, the economy, public health and livelihoods, especially of the poor (UN, 1992, Article 4(1)(f); Weiss, 2008).

The principle of intergenerational equity places obligations on the current generation to protect the climate system through mitigation and adaptation for their benefit and that of future generations. As far as it relates to intra-generational equity, there is a duty on governments to coordinate their responses to climate change with socio-economic development in an equitable manner in order to eradicate poverty for the long term. This places an obligation on states to respect, promote and fulfil human rights obligations in order to increase the ability, especially of vulnerable groups, to adapt to the adverse impacts of climate change for their wellbeing and development. Governments should therefore engage in adaptation planning and implementation processes, including national adaptation plans (NAPs) and climate change impact assessments, all of which must consider vulnerable people, places and ecosystems (UN, 2015, Article 7(9)). Additionally, governments have a responsibility to use the best available science, traditional knowledge and local knowledge systems to integrate adaptation into socio-economic and environmental policies and actions (UN, 2015, Article 7(5)).

Precaution places an obligation on a proponent, public or private, whose activities may lead to significant, serious or irreversible harm on the climate system to take or permit measures that prevent the damage from happening even where there is insufficient scientific certainty about the risks and severity thereof (UN, 1992, Article 3(3)). For all actors, this calls for measures to anticipate and stop potentially harmful activities and to stimulate innovation and participatory engagement in seeking the safest alternatives.

The responses to climate change, even at a domestic level, should also recognise that actors have common but differentiated responsibilities (CBDR) and capabilities (Maguire, 2012, p. 104). Therefore, different groups before the law require different rights and responsibilities to ensure a just and equitable climate change regime and outcome. Moreover, the polluter-pays principle creates liabilities resulting from harmful causal activities (Maguire, 2012, p. 104).

People-centred climate action calls for public participation and access to information and justice, which promotes the rights of people and involves them in decision-making processes. These principles are elaborated on in the Aarhus Convention (UNECE, 1998; Bekhoven, 2016, p. 240). Governments should take measures to facilitate the widest participation in climate action, including public access to information on climate change and its effects (UN, 1992, Articles 4(1)(i); UNFCCC, 2015). Capacity-building and education awareness are some of the ways in which participation is made possible for various actors (UN, 2015, Article 11). To enable access to information and public participation, relevant mechanisms should be provided for in plans, programmes and specific decisions at national and sub-national levels (Perlaviciute & Squintani, 2020). In addition, remedies must also be available for "injuries" and human rights violations in the climate change regime (UNFCCC, 2015, Preamble). Where the rights of people are violated by the impact of climate change, legal remedies must be available and accessible.

The engagement of all levels of government and various actors in climate change decision-making is dependent on good governance. This means adopting a multilevel, gender sensitive, participatory and fully transparent approach (UNFCCC, 2015, Article 7(4)). It calls for an altering of governance systems that sustain unsustainable production and consumption systems in key economic sectors, such as agriculture, energy, extractives and transportation. This further entails establishing, inter alia, new centres of economic power and new institutional actors and adjusting legal rights and responsibilities (Meadowcroft, 2010). However, apart from the typical governance challenges, such as corruption, states are forced to include unlikely actors in governance, to tackle antagonism from influential groups and to act timeously to address climate action, among other challenges (Meadowcroft, 2010, p. 1-2).

The common thread is in the principle of integration, which recognises the interdependence and interrelationship of economic, environmental, social and human rights issues in its climate change actions, responses and impact (UN, 2015, Preamble). This integration of climate action into broader socio-economic and environmental agendas is the basis for the mainstreaming of climate change into cross-sectoral national development planning as well as within sectors, in this instance, the extractive industry (UNDP, 2011).

Mainstreaming climate change action in the extractive industry

To appreciate the importance of mainstreaming climate action in the extraction industry, it is necessary to consider its value-chain activities that contribute to climate change and those that are affected by it, using the life cycle of a mining project (Segura-Salazar & Tavares, 2018). Typically, a mining project involves exploration, developmental and operational activities, mineral recovery and the closure or rehabilitation of the mine, as illustrated in Figure 6.1 (Gankhuyag & Gregoire, 2018, p. 30).

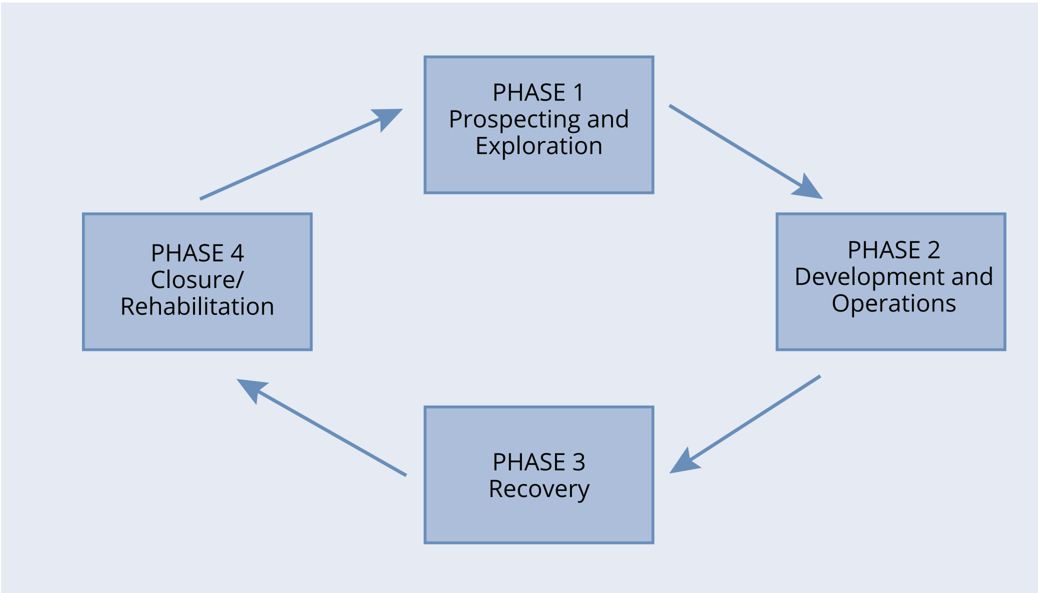

Fig 6.1. Typical mining project life cycle. (***Source:*** *Gankhuyag, U., & Gregoire, F. (2018). Managing mining for sustainable development: A sourcebook 30. New York: United Nations Development Programme (UNDP).*

According to Figure 6.1, the first phase in a mining project is the planning, which involves the key activities of prospecting and exploration. Prospecting is the most basic process of searching for mineral deposits, usually undertaken by individuals using unsophisticated techniques and equipment, and preceded by licences issued out by relevant government authorities (Carvalho, 2017, p. 73). At this level, it often leads to, or is accompanied by, exploitation at artisanal level with minimal knowledge of geology or of safe and efficient mining methods).

Formal exploration involves geological mapping of the area, core sampling, searching for outcrops, drilling and other methods (Westin, 1992, p. 185). Prospecting and exploration may not affect the environment, if there are no excavations but, where excavations happen, there is the clearing of wide areas of vegetation to allow the entry of heavy vehicles that are mounted with drilling rigs (ELAW, 2010). This has significant adverse effects on the environment and the climate system, with the reduction of carbon sinks and reservoirs (Westin, 1992, pp. 184-185). The second phase involves the development of the mine and the actual operation of the mine, both of which involve the clearing of vegetation and topsoil, resulting in, inter alia, the loss of biodiversity and fragile ecosystems, at a rate and scale commensurate with the scale of the mining project (Westin, 1992, p. 185).

Active mining, depending on the method and intensity and magnitude of the extraction, leads to subsidence, horizontal and discontinuous deformations of the ground surface and seismicity (Bell, 2017; Dubiski, 2013, p. 4). High volumes of gas and dust emissions are a result of the clearance and extraction (Dubiski, 2013, p. 4). The process of separating the minerals from the tailings makes use of hazardous chemicals, some of which are illegal, resulting in air, land and water pollution (Bell, 2017). The recovery processes, flowing from the operations, are also highly damaging to the environment, with high volumes of sulphurous gas emissions and, if the refining involves acid leaching, this is characterised by the percolation of acids through core dumps in order to capture minerals (Westin, 1992, p. 185). Finally, the closure and rehabilitation of the mine should involve reclaiming the mining site in order to return the land to its productive use to avert the continued environmental harm and degradation from dust, soil erosion, leaching, and the like (Westin, 1992, p. 185).

It is apparent that the entire life of a mining project leads to large amounts of air pollution, with emissions occurring at almost every stage of the mining cycle. The deforestation in artisanal mining and even during excavations in formal mining threaten carbon sinks and reservoirs. While the total carbon dioxide emissions vary depending on the type of resource being mined, as well as the methods employed, the industry has a high climate footprint (Rüttinger & Sharma, 2016, pp. 1-2). Yet, mining itself is particularly vulnerable to changing climatic conditions, which directly impact on operations and indirectly on the securing of supplies and the rising costs thereof (Rüttinger & Sharma, 2016, pp. 1-2). The infrastructure used in the mining cycle, such as containment facilities and buildings, energy sources, storm water, wastewater collection and treatment systems, tailings and waste-disposal ponds, and transportation infrastructure may be adversely affected by the extreme conditions caused by the changes in weather conditions and patterns (Ndlovu, 2018, p. 1). For instance, changes in water supply as a result of climate change affect the activities in the project cycle that are dependent on high volumes of water (Ndlovu, 2018, p. 1).

Together with the rises in temperatures, this may affect the working conditions in the mines, even exposing them to disasters and extreme weather patterns.

The livelihoods of the mining communities, already compromised by the mining activities, are worsened by the increase in sensitivity of their environments to these extreme weather patterns and natural disasters. Climate change also poses high risks of communicable diseases, exposure to heat-related illnesses and extreme-weather-related accidents for the workers and the mining communities (IFC, 2014, p. 26; Schuchard & Nelson, 2011). It is clear that the extractive industry should take measures to reduce, minimise and avoid GHG emissions and thereby mitigate climate change. Yet, in responding to the impact of climate change, the industry should take measures to adapt. It is therefore necessary to consider the legal tools that can ensure that the industry takes measures to mainstream climate change into its governance systems.

Legal tools for mainstreaming climate change into the extractive industry

There are a plethora of governance-based tools to address various issues in environmental governance. In the quest of exploring pragmatic tools for the mainstreaming of climate change into the extractive industry, the focus is on the command and control-based instruments, incentive-based instruments, agreement-based instruments and civil-based instruments (Du Plessis & Du Plessis, 2015).

Command and control tools prescribe a range of legislative standards, prohibition, and restrictions and sanctions in instances of contravention (Paterson, 2006; Junquera & Del Brío, 2016; Kidd, 2011, p. 210; Toxopeüs, 2015, p. 26). These may be in the form of specific mandatory legislative provisions and law enforcement sanctions, including criminal sanctions for direct contraventions of legislative provisions or subsidiary sanctions in the form of administrative measures (Du Plessis & Du Plessis, 2015, p. 117; Faure, 2011, p. 29; Kidd, 2011, p. 209, 220; Winstanley, 2009; Feris, 2006). The measures may include administrative penalties, which comprise monetary penalties imposed by the regulator without the intervention of the courts aiming to enforce administrative regulation by punishing non-compliance, deterring violations and creating incentives to improve compliance. Typical mandatory tools include pollution control laws, which create criminal or civil liability. Administrative tools include directives, environmental authorisation, licences, permits, compliance notices and withdrawal of authorisation to bring non-compliant actors into compliance with environmental legislation or with conditions of permits, authorisation or other regulatory instruments.

In regulating climate action, it is necessary for the government to impose mandatory provisions relating to sustainable use and emission reduction, to monitor compliance with these mandatory provisions, and to impose criminal liability as a means of deterring dangerous anthropogenic interference with the climate system (Bell, 2017). For instance, the destruction of GHG sinks and reservoirs, at any stage of the mining project lifecycle and in contravention of minimum mandatory provisions or standards, must attract criminal penalties for extractives companies' executives and managers (Odeku & Gundani, 2017; Bryne, 2010). In addition, applying a permit system for climate-related obligations for mining companies, such as management plans, work programmes, climate change-related impact assessments and other project-specific commitments, enables effectiveness in monitoring compliance and enforcement (Smith & Rosenblum, 2011).

For effective deterrence in the extractive industry, it is also necessary to reform traditional criminal law in order to curb repeated offences; for instance, adding to criminal sanctions the withdrawal of authorisation or permits and the revocation of certain rights for corporates and their executives (Wasahua, 2018). Yet, the weaknesses in over-regulating and overreliance on command-and-control tools validate the need to include other tools for mainstreaming.

Incentive-based tools, also referred to as market-based instruments, unlike command-and-control tools, act via an economic signal to influence the choices and decisions by corporates and consumers to which the relevant actors respond (Andersen & Sprenger, 2000; Faure, 2011; Paterson, 2006; Toxopeüs, 2015; Whitten, et al., 2003). It is essential, for sustainable use, to have investment incentives for the private sector to develop strategies that promote emission reduction, natural resource management and corporate social responsibility for climate resilience in the extractives industry (UN, 2015, Article 6(4)(b)). Incentivising climate action by extractive companies should be a developmental tool applied at national and local levels to attract new climate-smart mining investments (Jegede, 2016; Smith & Rosenblum, 2011). For existing companies, its value should be in complementing the monitoring of enforcement and compliance to mandatory provisions at a project level; for instance, the widely applied carbon tax should promote sustainable use of energy and other natural resources beyond what is prescribed in law, without passing on the costs of higher energy to society (Jegede, 2016, pp.99-100). The provision of financial assistance by government and external funding institutions for technological innovations is also crucial for efficiency in the extractives project cycle (Asfaha, 2007). Even for artisanal mining, the provision of financial assistance and other incentives should encourage sustainable projects in this subsector.

Agreement-based tools are voluntary commitments by actors to the enforcement process (Nel & Wessels, 2010). These tools are also voluntary compliance tools and are alternatives to command-and-control tools (Du Plessis & Du Plessis, 2015, pp. 128-129; Lehmann, 2009, p. 269; Newsome & Moore, 2015). The practice in the extractive industry is for project proponents to voluntarily subscribe to instruments such as certifications and best-practice codes and standards on responsible mining and environmental management. Policies and laws promoting these voluntary instruments are essential to strengthen and reinforce other regulatory tools for climate action in the extractive industry. Agreements between state actors, the private sector, local communities and civil society, including workers unions, are essential for defining their common but differentiated roles and responsibilities for adaptation in the extractive industry (Dyer et al., 2014; Balint & Mashinya, 2008). Effective application of the principles of public participation, access to information and access to justice must be the basis upon which all actors play a critical role in these agreements.

Public-private partnerships and community public-private partnerships for climate action are also essential in the extractive industry. PPPs are cooperative alliances between the public and private sectors, in different areas of intervention, which are traditionally inherent to the public sector but without embracing a complete privatisation process (Franco & Estevão, 2010; Paul, 2019, p. 1). These agreements should be structured according to the NAPs, NAMAs and broader national development policies and programmes.

The issues of extractivism for producer countries concerning the long-term benefits that are derived from the increase in demand for minerals used in renewable-energy technology are best provided for in terms of agreements. These agreements must secure socio-economic resilience for the producer countries and the producer communities (Chakanya, 2016; Paul et al., 2019). Issues around benefit-sharing for the improvement of the livelihoods and eradication of poverty for local communities and promoting local control or ownership of the mineral resources must be agreed upon in social licences to operate that are granted to the project proponents by these communities (Goswami, 2014; Vanclay et al., 2015; Boutilier, 2014, p. 264; Gibson & O'Faircheallaigh, 2010, p. 130; Morrison, 2014, p. 17). The terms of these agreements may be provided for in law, to establish formal agreements or, by negotiation, in informal agreements. Negotiations for workers' rights, their health and safety and their families are a way of addressing their equity and poverty issues relating to climate change (Ostensson & Roe, 2017, pp. 34-36; Dubiski, 2013, p. 5). The process of arriving at these agreements should reflect the procedural aspects of sustainability.

Civil-based tools are an alternative to command-and-control tools (Faure, 2011). These tools rely mostly on private actors, NGOs and civil society to assist, on the basis of equity, with improved compliance with the legislation that promotes climate action in the extractive industry (Westin, 1992; Du Plessis & Du Plessis, 2015; Higgins-Desbiolles & Whyte, 2015, p. 109). These tools include rights-based tools and civil action. Rights-based tools predominantly relate to the enforcement of environmental procedural rights in decision-making and climate action negotiations by and between the various actors (Du Plessis, 2015, p. 91-166; Toxopeüs, 2015). However, an environmental-rights approach to other human rights is an essential tool for constitutionalising climate change and thereby creating the platform for promoting equity in climate action by the government and private sector (IBA, 2014, p. 47; Amechi, 2009; Faure, 2011; Feris, 2008; Ruppel, 2010; Schall, 2008; Van der Linde & Louw, 2003, pp. 173-177).

A human-rights approach also positions climate change governance as a tool to address other rights, including workers' rights and other vulnerable groups. These human rights tools are important for advancing climate change litigation, on the basis of the precaution and the polluter-pays principle, by affected individuals and communities and interest groups, including civil society (UNCTAD, 1994; Olenasha, 2001, p. 24-25; Boyd, 2011, pp. 45-77; Du Plessis, 2008, p. 193; Toxopeüs, 2015, pp. 32-36). Therefore, issues of locus standi, which normally preclude group action, should be addressed in the enabling legislation.

The enforceability of human rights itself is by way of civil action, which creates civil rather than criminal liability where harm or damage may be imputed. Notwithstanding the hurdles in litigation, this is an avenue for enabling compensation for victims suffering harm as a result of incidents involving hazardous activity (Maguire, 2012, p. 104). However, unless otherwise provided for in common law, civil liability for climate-related environmental harm must be provided for in specific legislation, especially where it relates to the specific actions of corporate entities, their executives and employees causing pollution and environmental degradation (Tilton, 1995, p. 139; Du Plessis, 2008, p. 224).

Common law remedies also exist for claims from the law of delict, nuisance and neighbour law that may relate to corporate liability. They may also exist for public nuisance actions and destruction of property claims those affected by climate events to seek redress or injunctive relief from the state (IBA, 2014). An extension of these common-law liabilities to climate change litigation will be a progressive step in mainstreaming climate change in the extractive industry.

Evidently, mainstreaming climate change in the extractive industry is not in singling out a specific set of tools, but in combining them for the best possible results (Nel & Wessels, 2010). A deliberate effort to use them to mainstream climate change into the extractive industry remains a priority.

Assessing country progress in mainstreaming climate change in the extractive industry (mining)

An assessment of selected SADC member states that are also member states of the international climate change regime, namely Botswana, South Africa and Zimbabwe, is necessary to determine the strides that have been made particularly in the mining industry to mainstream climate change. The countries ratified the UNFCCC in 1994, 1997 and 1992 respectively, and have all ratified the Paris Agreement, Botswana and South Africa in 2016 and Zimbabwe in 2017. Botswana is particularly vulnerable to climate change as a landlocked country with arid to semi-arid climatic conditions that expose it to droughts and desertification (Nachmany, 2015). Its mining industry, dominated by the mining of diamonds as the world's leading producer, contributes about 10 percent to the GDP. Other minerals that contribute significantly to the economy include copper, gold, nickel and soda ash.

South Africa produces about 59 different minerals from 1115 mines and quarries, thus making the sector a major contributor to the GDP and employment.

It contributes directly and indirectly to climate change from emissions from coal mining and large-scale mining with open-cast mines. The industry is at risk from the variability of climatic conditions affecting mining operations and technologies as well as secondary impacts of climate change (South Africa, 2020).

Zimbabwe is a landlocked semi-arid country whose climatic conditions have been changing for the past 30 years, with increased temperatures, reduced rainfall and frequent and recurrent droughts, flooding and severe storms (Zimbabwe, 2015). The most pertinent environmental challenges include deforestation, soil erosion, land degradation and pollution of the air and water, attributed, in part, to unsustainable mining practices. Mining in Zimbabwe is a major economic sector, after agriculture and manufacturing, contributing about 44 percent to the country's GDP. Of the many minerals it produces, the following are the major ones: gold, platinum, nickel, chrome, iron ore, coal, gypsum, granite, phosphates, lithium and diamonds. Open-cast mining, which is the most common mining method, has led to widespread environmental harm and degradation caused by blasting, the use and production of coal, and the clearing of forests and woodlands. Artisanal small-scale mining is also widely practised, most of which is illegal, worsening desertification, pollution and environmental degradation (Zimbabwe, 2015, pp. 39-40).

Against this background, Table 6.1 provides an overview of the principal legislation relating to climate change and mining as well as the respective tools.

Table 6.1. Existing domestic tools for mainstreaming climate change in the mining industry

	Botswana	South Africa	Zimbabwe
Principal climate change legislation	No specific legislation. Has the National Climate Change Policy and Strategy and Action Plan (NCCPSAP) and National Development Plan recognises mainstreaming. Atmospheric Pollution Prevention Act (Chapter 65:05) 18 of 1971 (vague on emissions reduction).	Climate Change Bill; National Climate Change Response Policy, 2010 (NCCRP); National Climate Change Response Green Paper, White Paper on the National Climate Change Response; South Africa's Nationally Determined Contribution, National Environmental Management Act (NEMA) regime; the National Environmental Management: Air Quality Act, 2009 (NEM:AQA), Constitution of the Republic of South Africa Act 108 of 1996.	No specific legislation. Has the National Climate Change Policy of 2017 (NCCP); National Climate Change Response Strategy of 2015 (NCCRS), Vision 2030.
Principal mining legislation	Mines and Mineral Act (Chapter 66:01) Act 17 of 1999; Environmental Impact Assessment Act (Chapter 65:07) 5 of 2005; Draft National Energy Policy	Mineral and Petroleum Resources Development Act (MPRDA) 28 of 2002 has an integrated approach with NEMA regime; National Water Act 36 of 1998; Mine Health and Safety Act 29 of 1996; the Constitution;	Mines and Minerals Act (Chapter 21:05) Act 31 of 1961; Environmental Management Act (Chapter 20:27) Act 13 of 2002 (hereafter EMA)

	Botswana	South Africa	Zimbabwe
Command-and-control tools	Available but with indirect application to climate action; e.g. environmental obligations during the project cycle and concomitant criminal liability for contravention; EIAs;strategic environmental assessments; safe excavation procedures; administrative directives for waste management, dumping prohibitions, rehabilitation and reclamation measures. special mining licences for concession areas;	Emissions controls; proposed hefty criminal penalties; EIAs; environmental management programme/ environmental management plan; mining licences and public participation processes; environmental conditions for prospecting and mining rights; atmospheric emission licences; NEM:AQA plans; water use licences; social and labour plans; controlled emissions and fuels;	Environmental plans & environmental management plans; EIAs and environmental authorisations; public participation procedures; environmental audits; pollution and waste-management licences and concomitant criminal liability; prohibitions on veld fires and on wetlands and public streams; criminal liability for forest prohibitions.
Incentive-based	None of direct application.	Carbon pricing, carbon tax, carbon markets and biodiversity conservation and management incentives; emissions trading schemes.	
Agreement-based	International mining standards and certification.	Environmental cooperation agreements; a robust constitutional and mining and environmental human rights approach.	

	Botswana	South Africa	Zimbabwe
Civil-based tools	Civil liability for environmental harm; No apparent human rights approach.	Civil liability for mining directors for pollution or ecological degradation and occupational & human health.	Civil liability for remedial action; cancellation of licence; constitutional environmental rights approach.
Key points in analysis	The indirect application of these tools does not facilitate mainstreaming as they should.	South Africa's climate change and mining regime together are progressive for mainstreaming climate.	The existing tools are not comprehensive for mainstreaming as they address mitigation actions in the industry without much on adaptation.

From the above, it is clear that, save for South Africa, which has made significant strides in developing climate change legislation, as well as a robust integrated mining and environmental approach buttressed with specific climate change tools, Botswana and Zimbabwe rely heavily on the indirect application of their tools to climate change action. This over-reliance on indirect tools waters down specific mitigation adaptation measures for the extractive industry and suggests that specific tools are still necessary to facilitate mainstreaming of climate change in the extractive industry.

Conclusion

The mainstreaming of climate change in the legal framework of the extractive industry is influenced by the principles of sustainable use, equity and eradication of poverty, precaution, polluter-pays, CBDR, public participation, access to information and justice, good governance and integration, as they are framed in climate change law. Their application to the extractive industry is specific to the activities that are characteristic of the different stages in the mining project life cycle. These activities must then be governed by a combination of specific governance-based tools.

An overview of the existing tools in Botswana, South Africa and Zimbabwe reflect that, in the absence of specific climate change legislation, it is not enough to have indirect legislation and tools as these do not facilitate the mainstreaming of climate action into the extractive industry. It is therefore crucial to have specific laws and tools for addressing climate change in the extractive industry.

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7

An Analysis of SADC Mining and Environmental Legal Frameworks in Response to Sustainable Development Goal 13 on Climate Action: The Case of Zambia

Owen Murozvi

Abstract

The United Nations General Assembly included the global environmental concerns on climate change in its Sustainable Development Goals of 2015 (SDG13). This paper reviews SADC's efforts in addressing climate change challenges. Its main aim is to investigate recent developments in the formulation of harmonised SADC laws and policies on climate change in general and laws and policies pertaining to climate change and the nexus with the extractive sector. The central hypothesis of the paper is that a harmonised sub-regional law and policy is needed to regulate all SADC member states' response mechanisms to climate change. Furthermore, various international, African Union and SADC legal instruments stress the crucial role of harmonised law and policy as an important climate change adaptive measure. In effect, the paper gives an overview of the policy and institutional framework on the actions/strategies taken to mitigate and adapt to climate change in Southern Africa particularly in Zambia and outlines the positive effects in the nexus of climate change and the extractive industry for both the protection of the environment and economic development. As policy and legislation are essential for dealing with the unavoidable impact of climate change in mining and other extractive sectors, the paper attempts to analyse the legislative and policy frameworks that regulate the sector.

Introduction

Climate change is defined as the long-term weather condition of a region and its pattern of change over time (IPCC, 2013). This change is attributed to the warming of the earth due to the contribution of emissions arising from human activities and greenhouse gases (GHG), which changes the natural greenhouse effect. These emissions are linked to fossil-fuel burning, which supports the economic sector consisting of industry, automobiles, the energy demands of modern-day living, and other related activities (Jegede, 2016; Gore, 2006). Although not every impact of climate change is adverse and negative, there is plenty of evidence of these harmful consequences that are recorded across Africa despite the continent contributing little to the cause of adverse greenhouse effect (Toulmin, 2009).

According to the Preamble of the Paris Agreement and the United Nations Sustainable Development Goals, Goal No. 13 of 2015, climate change is a global concern, due to its adverse effects on mankind (UNFCCC, 2015a). The concern was included as one of the goals that form a part of the 17 Sustainable Development Goals (SDGs) to end poverty, fight inequality and injustice, and tackle climate change by 2030, which were adopted by world leaders at the United Nations Sustainable Development Summit on 25 September 2015 (UN, 2015). Pertaining to Southern Africa, many authors have noted that climate change and related hazards are projected to rise in degree, but the nexus of climate change and the extractive industry, and more importantly their implications for the protection of the environment and economic development, are not yet fully explored (Niang et al., 2014). Thus, an increase has been noted in the past decades of discussion on a changing climate and its link with the extractive activities of mined raw materials in Africa, such as oil, metals and minerals, for processing and production (Horsley et al., (2015).

The extraction of minerals from the earth presents opportunities, challenges and risks to sustainable development and the environment. Thus, this paper argues that the nexus of climate change and the extractive industries can have both negative and positive implications for environmental protection and the economy in Africa. While mineral extraction is essential for human wellbeing and is fundamental for virtually all sectors of the economy, mining presents critical challenges and risks for sustainability.

The nexus of climate change and the extractive industry in Southern Africa

Water resources, food security, natural resource management and biodiversity, human health, settlements and infrastructure are some of the vulnerable sectors to climate change. In this era of climate change, there has been a noted unprecedented growth in the extractive sector in Africa. For instance, studies have shown that increasing national revenues are derived from natural resources, particularly mining in Zambia (Stevens, Lahn & Kooroshy, 2015). These mining activities have also created a multitude of income opportunities for inhabitants of these resource-rich areas. In relation to metallic minerals, it has been reported that, from 2005 to 2012, the annual global production of iron ore, gold, silver, and copper increased by 10 percent, 1 percent, 2 percent and 2 percent, respectively (Kelly & Matos, 2013). This growth is largely driven since 2008 by consumption in China, India and developed countries (UNCTAD, 2008). China is reported to have imported 50 percent of the world's total iron ore exports and produced about 50 percent of the world's pig iron, in 2008 alone. The same reports indicated that India took up 35 percent of the world's total gold production in 2011, while the United States of America consumed 33 percent of world's total silver production in 2011 (UNCTAD, 2008).

More recent evidence, in particular, shows that the economy of Africa has been in the supply chain. For example, in Zambia when re-privatisation started and the government decided to unbundle Zambia Consolidated Copper Mines (ZCCM) into smaller units, new mine owners invested massively in the mines and there was a sudden economic upturn. The upturn was not just in the Copperbelt, but also the country as a whole, with the mining industry as a pivotal contributor. Investments went into new machinery and so did new mining methods and new mineral-processing and metal-extraction technologies. There were also massive greenfield projects at Kansanshi and Lumwana, both in the North West Province, which brought newer technologies into the industry. These mines were able to process large quantities of low-grade copper ores at very low costs, thus representing a marked increase in mining activities in Zambia (UNCTAD, 2008).

Climate change is then linked to these extractive activities in the sense that hazards associated with it, such as high precipitation levels, flooding, windstorms, erosion and extremes in temperature also adversely affect different areas of the mining sector, namely the inputs of water and energy, people, supply chains, markets, exploration, construction, operation, closure and post-closure and arguably undermine economic growth. It was also found that greater intensity and frequency of storms associated with flooding and changes in waterbeds are linked to the closure of mining activities (ICMM, 2013; Locke, Clifton & Westra, 2011).

Climate change will affect exploration and mining and quarrying industries. An increase in climate-related hazards (such as forest fires, flooding, and windstorms) affects the viability of mining operations and potentially increases operating, transportation and decommissioning costs (Arente et al., 2014). These extreme conditions, such as rising temperatures, flooding, stronger wind and frequency of precipitation will weaken structural integrity, bridges, pipelines and walls, thereby compromising the accessibility of mining sites and safety in operations (Boyle et al., 2013, pp. 1-40). In addition, hazards such as forest fires resulting from heat waves and other risks will affect accessibility, thereby reducing the viability of mining operations.

Similarly, evidence of the nexus of climate change with the extractive industry exists in the sense that climate-related risks are affecting the viability of the extractive sector, which may undermine economic development in countries such as Zambia. For instance, extremes in temperature and associated events, such as flooding, are regular features in the frequency and duration of cholera outbreaks in African states. This development compounds the health and safety of workers in the mining sector as well as adjacent local communities in countries such as Tanzania, Ghana, Zambia and Zimbabwe, which are already confronted by grave environmental challenges (WHO, 2014). These people are at risk as they are exposed to serious environmental health hazards resulting from exposure to mercury and lead associated with mining, which can endanger their vital organs, including the kidneys, the cardiovascular and immune systems, and thus slow down their contribution in a sector that is at the heart of the African economy (Nweke & Sanders, 2009).

Climate change in Southern Africa is predicted to worsen water scarcity by 65 percent in 2025 affecting countries like Zambia, Zimbabwe and South Africa. This scarcity is envisaged to adversely affect the extractive sector as water is critical to mining operations for dust suppression, product separation and crushing, concentrate and waste transport, and further processing of minerals (Ranchod et al., 2015). To improve resilience, companies can reduce the water intensity of their mining processes. They can also recycle used water and reduce water loss from evaporation, leaks and waste. The implication for the extractive sector in Africa is that a limited availability of water will constrain the operations and production of mining activities.

Climate change also adversely affects the supply chain of the extractive industry in that operations require effective transport and coastal port facilities, which are vulnerable to disruption such as rising sea levels, flooding and storms associated with climate change (ICMM, 2012). Research shows that climate change has a negative effect on the coastal potential for trade in different regions of Africa (USAID. 2013). Arguably, this trend will impact supply chains and trade in extractive materials and may slow down economic development. A changing climate affects markets for goods and products from the extractive sector. For example, the need to address climate change may lead to a reduction in the demand profile for metals and minerals from carbon-intensive mining activities. The possibility is emerging that developed states may apply trade measures such as carbon tariffs or border restrictions on carbon-intensive minerals of developing countries, including Africa (SASB, 2014).

Other risks associated with climate change in the industry will be on construction infrastructure. A changing climate has the potential to affect ground temperature and weaken mining structures thereby encouraging closure and post-closure activities (Ndlovu, 2016).

What then are the implications of the nexus of climate change and the extractive sector for environmental protection and the economy in Africa? It is argued that the link of the extractive industry with climate change can have both negative and positive implications for environmental protection and the development of the economy.

SADC mining and climate change legal framework

Introduction

Climate change as an environmental challenge is without borders or geographical limits. While climate change is globally caused, its impacts are locally felt and nowhere more so than in vulnerable regions such as Southern Africa. The transboundary nature of climate change and its impacts calls for a harmonised approach. At the African Union (AU) level, the AU-NEPAD African Action Plan 2008 expressly states the important role harmonised regional policies will play in adapting to climate change. Moreover, at the international level, the development of laws and policies related to climate change originated in the establishment of the United Nations Intergovernmental Negotiating Committee in 1990 and the subsequent drafting of the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. Below are an outline and analysis of the existing legal and policy frameworks in SADC.

The Paris Agreement

The Paris Agreement on Climate Change was adopted at the 21st conference of parties (COP21) that took place in December 2015, in Paris, France (UNFCCC, 2015a). The agreement builds upon the UNFCCC and for the first time brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. Thus, it charts a new course in the global climate effort through GHG emission reductions.

The Paris Agreement came into effect on 4 November 2016. A total of 196 country parties reached a consensus on the need to reduce GHG emissions, thereby making the agreement a unifying treaty in the world's efforts to combat climate change. Countries in Southern Africa, including Zambia, are signatory to the agreement, which prioritises adaptation actions with mitigation co-benefits in addressing climate change while subscribing to the principle of common but differentiated responsibilities in line with national capabilities as enshrined in the UNFCCC.

The implementation of the various provisions of the Paris Agreement commenced in 2020. The agreement's central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C (UNFCCC, 2015b, Article 2). In addition, it aims to strengthen the ability of countries to deal with the impact of climate change. To reach these ambitious goals, appropriate financial flows, a new technology framework and an enhanced capacity-building framework will need to be put in place, thus supporting action by developing countries and the most vulnerable countries in line with their own national objectives. The agreement also provides for enhanced transparency of action and support through a more robust transparency framework.

The Rule Book for the implementation of the Paris Agreement, which was agreed upon at the 24th conference of parties (COP24), calls upon all countries to report on their domestic actions to curb the rises of emission levels according to the transparency framework. It stipulates that reporting GHG emissions and climate finance has to be done both thoroughly and more frequently (UNFCCC, 2015b, Articles 7 and 9). Countries are called upon to increase their aspiration levels in GHG emission reduction and adaptation efforts within the framework of economy-wide nationally determined contributions and the global goal on adaptation.

At the SADC level, the important adaptive role of harmonised regional policies is recognised by a number of provisions contained in various regional instruments. Article 5(2) (a) of the Treaty of the Southern African Development Community, 1992 (SADC Treaty) states that, in order for the region to attain the objective of sustainable development, there is need to harmonise political and socio-economic policies and plans of Member States (SADC, 1992).

Southern Africa Climate Change Framework, 2010

The 2010 framework is a brainchild of the SADC-CNGO policy paper on climate change. The paper had outlined the following as the key SADC positions to be taken to the 17th session of the conference of the parties (COP17) held in Durban, South Africa, from 28 November to 11 December 2011: legally binding emission reduction targets; funding support for climate change; rejection of private market mechanisms; women-focused interventions; adaptation; mitigation; technology transfer; just transition; national policies and strategies; and, ecological debt (Pressend, 2011). The paper then paved the way for further consultation among SADC member states on their shared position on climate change for COP17, which resulted in the drafting of the Southern Africa Sub-Regional Framework on Climate Change in 2010.

Even though the framework is only an indicative framework and therefore not legally binding among SADC member states, it was a good start, as it makes recommendations to SADC countries to streamline climate change responses at the sub-regional level. The framework lays out priorities for the region, such as adaptation, mitigation, financing and technology transfer as well as provision for review mechanisms for responses to the climate crisis by member states. Significant growth of low-carbon technologies will be a key priority and will occur if industries commit to cutting emissions and adopt technologies that support decarbonisation, including wind turbines, solar photovoltaics, electric vehicles, energy storage, metal recycling, hydrogen fuel cells and carbon capture and storage.

At the other end of the spectrum, niche minerals like cobalt, lithium and nickel could experience dramatic growth, as the global electrification of industries continues (electric vehicles and batteries). Emerging technologies such as hydrogen fuel cells and carbon capture would boost demand for platinum, palladium and other catalyst materials, while rare-earth minerals would be needed for wind-turbine magnets. Mitigation by the energy sector is seen to be the domain of those countries that are huge carbon emitters, most notably South Africa with its carbon-intensive energy sector (UN, 2015, Article 2).

In conjunction with the provisions of the climate change framework, COP17 also introduced voluntary mitigation actions on developing countries, which, in the context of energy-sector reform, refer to a transition to a low-carbon economy (Barnard, 2014).

The SADC climate change strategy

The aim of the SADC climate change strategy and action plan is to provide a broad outline for harmonised and coordinated regional and national actions to address and respond to the impact of climate change in line with global and continental objectives. The strategy aims to promote the use of resources efficiently in the mining sector and the mainstreaming of climate change into mining operations. It guides the implementation of the climate change programme over a 15-year period (2015-2030) and provides a short, medium- to long-term framework for implementing elaborate and concrete climate change adaptation and mitigation programmes and projects.

A closer look at the mining subsector of the strategy highlights the fact that mining is an industry of strategic importance in Southern Africa. Roughly, half of the world's vanadium, platinum and diamonds originate in the region, along with 36 percent of gold and 20 percent of cobalt. Mining activities can also contribute to sustainable development, particularly to its economic dimension. It can bring fiscal revenues to a country, drive economic growth, create jobs and contribute to building infrastructure. The industry impacts all 17 of the Sustainable Development Goals (SDGs) to varying degrees, through mining itself, social investments, taxes and the investment of public revenue.

The mining protocol

The SADC Mining Protocol came into force in February 2000 after ratification by member states. The objective of the protocol is to create a thriving mining sector that can contribute to economic development, alleviate poverty and improve the standard and quality of life in the region. It aims to develop the region's mineral resources through international collaboration, in turn improving the living standards of the people engaged with the mining industry. Because mining can be a hazardous undertaking, the protocol also requires that member states observe internationally recognised health and safety as well as environmental protection standards.

As a way of ensuring sustainable environmental protection, the protocol calls upon member states to promote sustainable development by ensuring that a balance between mineral development and environment protection is attained. This also entails that member states take a regional approach in conducting environmental impact assessments, especially in relation to shared systems and cross-border environmental effects. Through the protocol, there is a collaborative approach in the development of programmes to train environmental scientists in fields related to the mining sector and to undertake to share information on environmental protection and rehabilitation.

The protocol lay down the basis on which the mining sector can be regulated to reduce both its contribution and vulnerability to climate. In order to implement it, the SADC Mining Strategic Plan was drafted as the operational instrument aimed at achieving the protocol's objectives, among them the issue of environmental protection, and dealing with environmental standards and initiatives in the sector.

Conclusion

The major weakness within the SADC framework as to climate change related issues is the lack of clear climate change agendas (Ruppel, 2013). Although some relevant provisions can be traced in various sectoral legal instruments, there is no clear roadmap, such as a consolidated strategy or action plan, charting the course on how to deal with climate change in general, neither mitigation nor adaptation in particular (Ruppel, 2013). The SADC lacks a single, coherent overall regional policy on climate change, as evidenced by the various separate policy instruments. A regional climate change policy, mostly on mitigation and adaptation, is critical to guide the activities of the 15 member states, to ensure that the region-wide climate change policy objectives are clearly defined and pursued through commonly agreed objectives that are clearly defined and pursued through commonly agreed strategies.

Zambia's legal and institutional framework

Introduction

Mineral exports are important to many countries' economies. In Zambia, for instance, copper contributes about 80 percent to the country's export earnings (Brülhart, Dihel & Kukenova, 2015). Zambia's dependence on copper means that when its prices fall, as they did in the 1970s and in 2008, so too do government revenues. The country has thus struggled to maintain macroeconomic stability as it has been left vulnerable to supply disruptions and to high import-price volatility; its ability to benefit from the increased value of refined oil products is limited (Christopher, Collier & Gondwe, 2014; AfDB. 2013a). Regulating the mining sector can help Zambia reduce the contribution of mining to climate change while reducing its vulnerability to climate change.

Due to its direct physical environmental impacts, the mining sector in Zambia has always been regulated. This has been through several legal instruments including legislation, policies and regulations.

Legal framework

An adequate climate change legislative framework is central to the effective mitigation of the effects of climate change. Zambia must build on lessons learnt from other countries that have developed such comprehensive frameworks in order to create a hybrid structure that satisfactorily addresses the needs of the country. There is a real risk that, if there is no climate change legislation in place, the country may not be able to deal with the detrimental consequences of climate change. A cavalier attitude towards climate change issues must now change and government must take concrete steps in this regard.

A close study of the legal framework shows that the Zambian government has put in place a comprehensive mechanism for an integrated approach to climate change. The sector ministries regularly review their relevant policies and legislation, in order to ensure they are in line with the objectives of the National Policy on

Climate Change and other initiatives meant to tackle climate change. The country's institutional framework is anchored by this policy in order to support and facilitate a coordinated response to climate change issues. The framework helps with efforts to re-align its climate-sensitive sectors of the economy and its society in order to meet its development goals through adaptation and mitigation interventions.

The National Policy on Climate Change presents important sustainable development opportunities through a well-structured national strategy that is envisaged to effectively combat the adverse effects of climate change. The initiative to mainstream the policy in the Ministry of Development Planning ensures stronger collaboration between various ministries that have a role to play in climate change mitigation and adaptation. This will ensure coherence between National Development Plans and all climate change programmes. The multi-sectoral approach sets the framework and tone for success in implementing projects and programmes through coordination via institutional frameworks and provides the country with home-grown strategies that will enhance efforts aimed at limiting the impact of climate change on national development.

Zambia's carbon footprint and the emergence of climate change as one of the most globally pressing issues to current socio-economic development provides new opportunities in the energy, agriculture and other sectors. These are discussed below, examining their potential to regulate the mining sector in the light of the challenges presented by climate change.

a. *The Constitution of Zambia*: The constitution, as amended by Act 2 of 2016, is the supreme law, and "if any other law is inconsistent with it, that other law shall, to the extent of the inconsistency, be void" (Zambia, 2016a, Article 1(1)). The state is required, under the constitution, to put in place mechanisms aimed at reducing waste, promoting relevant environmental management systems and tools, and ensuring that the environmental standards that are enforced in the country essentially benefit the citizens (Zambia, 2016a, Article 257(b)(c)(f)). The constitution has put in place certain principles that must govern the development and administration of the environment and its natural resources (Zambia, 2016a, Article 255). Although it does not explicitly mention climate change, it has strong provisions on the environment and sustainable development. It calls for the establishment of policies, legislation and institutions that have a direct and indirect bearing on the environment and climate change.

b. *Mines and Minerals Development Act 11 of 2015*: Zambia's mining industry is principally regulated by the Mines and Minerals Development Act No. 11 of 2015 (the Mines Act) and the regulations issued thereunder. In particular, section 4 recognises the principle of sustainable development by calling for the use and development of mineral resources in a manner that takes into account the needs of present and future generations (Zambia, 2015, Section 4(a)). This section further goes on to provide that the exploitation of minerals shall ensure safety, health and environmental protection (Zambia, 2015, Section 4(c)). The more instructive provisions relating to mine closure are found in sections 81, 82, 83 and 86 of the Mines Act. First, Section 81 provides that the conditions subject to which a mining right is granted or renewed shall include certain conditions prescribed by the Minister of Mines. The conditions may be in relation to rehabilitation, levelling, re-grassing, reforesting or contouring of the part of the land over which the right or licence has effect as may have been damaged or adversely affected by exploration operations, mining operations or mineral-processing operations and the filling-in, sealing or fencing of excavations, shafts and tunnels (Zambia, 2015, Section 81(1)(c), (d)). This includes a further requirement imposed on an applicant for the grant or renewal of a licence, or the holder of a licence, as the case may be, to lodge one or more cash deposits for securing the performance of the conditions by the applicant or licence holder.

c. In section 82, the Mines Act gives an instruction to the holder of a mining or mineral-processing right to clear away all mining and mineral processing plant on the land that ceases to be subject to a mining right or mineral processing licence. This must be done within a period of six months following cessation of the mining right or mineral-processing licence, or within a period specified by the Director of Mines Safety (Zambia, 2015, Section 82(1), (2), (3)). Where any mining or mineral-processing plant is not removed, section 83 prescribes the ways in which the state will dispose of it and how the proceeds of the sale will be apportioned.

d. Section 86 establishes the Environmental Protection Fund and gives a short description of how the money contributed to the fund is applied. One progressive provision in the new Mines Act is that it expressly grants the minister the power to make regulations that should specifically deal with the decommissioning and closure of mines (Zambia, 2015, Section 119(2)(d)).

e. *Environmental Management Act No. 12 of 2011*: The Act is the principal law that captures all aspects relating to the protection of the environment against harm from human activities. Section 5, for instance, begins by stipulating that every person has the duty to safeguard and enhance the environment. Section 6 then goes on to stipulate various principles of environmental management upon which mine closure is premised. These include the polluter pays principle, the people's right to participate in the development of policies, plans and programmes for environmental management, long-term integrated planning against adverse environmental impacts and sustainable development (Zambia, 2011, Section 6(d), (f), (b), (j)).

f. Section 29 of the Act is the most relevant provision with respect to the mine closure. In particular, this section prohibits persons from undertaking any project that may have an adverse effect on the environment without the written approval of the Zambia Environmental Management Agency (ZEMA). This approval is essentially granted upon ZEMA's consideration of an environmental impact statement (EIS). Further, there is a prohibition on other appropriate authorities from granting licences for the execution of projects likely to have an adverse impact on the environment without the approval of the project from ZEMA (Zambia, 2011, Section 29(2)). The Act also provides for integrated environmental management through the protection and conservation of the environment and the sustainable management of natural resources, including all mandates relating to the prevention of and control of pollution and environmental degradation. The Act also provides for the promotion of public awareness, information-sharing and education on climate change impacts and effects. Lastly, the Act also seeks to control and manage emissions from the industry.

g. *Energy Regulations Act No. 23 of 2003*: The Act among, other issues, regulates energy and how efficiently it is used. In one of the key provisions, it

> promotes the scaling-up of alternative energy sources such as solar, wind and geothermal, as well as energy efficiency and conservation. It also seeks to provide electricity supply to rural areas to enable more people access it, with the anticipation that it will lead to the reduction in the demand for wood energy. The Act also makes provision for the upgrade of petroleum by the blending of oil and fuel so as to reduce carbon emissions. There is an urgent need to change the processes used in the extractives industry, which is highly energy-intensive, if Zambia is to achieve the objectives of the Energy Regulations Act.

Transportation is another major source of GHG emissions from the extractives sector, given that minerals and fossil fuels, as well as waste products, must often be hauled over long distances. In effect, there is need for upgrading to newer and more efficient and low carbon transport technologies that offer an opportunity to reduce GHG emissions in mining and quarrying processes and fossil-fuel production processes, often producing a net economic benefit during the lifetime of a project. However, energy efficiency upgrades frequently require significant investment, resulting in potentially lengthy payback periods (Cantore, 2011).

The Energy Regulations Act should do more in compelling the Zambian extractive sector to shift from diesel-powered machinery to low-carbon energy sources, as a GHG-mitigation strategy (Cantore, 2011). However, financial and technical capacity challenges will need to be overcome in order to achieve this level of deployment. The off-the-grid nature of many mining sites, which can be located in remote areas away from energy infrastructure, makes them well-suited to a renewable energy power supply.

Zambia has strategic choices to make about the resource intensity of its economy. There is a need to analyse the long-term and short-term implications for energy costs and competitiveness, bearing in mind the relative infancy of the country's economy and the nascent stage of energy and industrial infrastructure. The government should play a key role by supporting the development of renewable energy in the extractives sector, and by setting a clear and strategic policy framework that creates a stable business environment for renewable-energy investment. This can range from command-and-control regulations, such as a mandate for a certain percentage of electricity coming from on-site renewable energy generation, through to market-based mechanisms such as tax breaks for imports of renewable energy equipment and information campaigns for mining companies and employees.

Recommendations on changing the climate of mining

Climate change presents both challenges and opportunities for the mining and metals industry in SADC in general and in Zambia in particular (ICMM, 2011). An effective climate change control mechanism in mining must reflect a synergy between mitigation (being global and long-term) and adaptation (which is local and short-term) structural changes. The issue of addressing climate change in the mining sector would require long-term solutions, including drawing up appropriate policy guidelines, institutional capacity-building and the deployment of adequate resources (Nwamarah, 2012). Some of the recommendations that are proffered are as follows:

a. *Enhancement of alternative energy use:* According to Article 4 of the UNFCCC (1992), for instance, adaptation and mitigation are the two global responses to adverse climate change (UN, 1992, ILM 851). Examples of these measures include projects promoting renewable sources of energy under Article 2, paragraph 1(a)(iv) of the Kyoto Protocol (UN, 1998). The promotion of alternative sources of energy and the avoidance of deforestation can contribute to the sustainable growth of the extractive industry and thereby positively impact the protection of the environment and the economy.

b. *The development of alternative sources of energy:* could also reduce carbon emissions and enhance mining that is climate-friendly. Projects such as reforestation and afforestation, which are linked to environmental protection, may result from the climate change and extractive industry nexus, not only because they could form part of the closure and post-closure activities of the mining operation, but also because their accommodation in mining-operation design could serve the use of assessing the seriousness of the government to prevent environmental harm. Similarly, the fact that the REDD+ initiative could help to prevent the exploration of forests rich in natural resources could help reduce the over-reliance on the extractive sector and thereby guarantee the sustainable use of non-renewable resources for the present and future generations.

c. *The green economy as an enhancer of natural resource efficiency:* Defined as an economy that can result in improved human wellbeing and social equity, while significantly reducing environmental risks and ecological scarcity, the idea of the green economy uniquely suggests that the extractive industry can be engaged in a manner that enhances the protection of environment and, therefore, reduces emissions which contributes to climate change. The concept of the green economy is thus an attempt to depart from a business-as-usual approach. Through an emphasis on low-carbon, resource-efficient, public and private investments that reduce carbon emissions and pollution in enhancing energy and resource efficiency, the notion of the green economy could prevent the loss of biodiversity and ecosystem services. The notion could prevent the focus on the overuse of non-renewable natural resources, which essentially forms the extractive sector, and promote better management of natural resources thereby limiting the carbon imprint of involved activities on the climate.

d. *Sustainable management of natural assets has been suggested:* as a key feature of green growth and resilience to natural disaster and climate change effects (AfDB, 2013b). It is envisaged that the development of a climate-resilient, low-carbon economy rests on pillars that include sustainable land-use management and climate-compatible mining. In addition to the notion of the green economy, which spotlights natural-resource efficiency, another emerging mechanism for environmental protection that is associated with climate change and the extractive industry is carbon tax.

e. *Carbon tax can reduce emissions associated with the extractive sector*: Carbon tax is connected with the extractive industry and, by implication, with environmental protection because it aims at addressing the emissions of GHGs associated with the combustion of coal, gas and oil, underlying global warming. It refers to a tax on the carbon content of fuels (WTO, 2010). The tax has been shown as an effective option for reducing GHG emissions and is an efficient tax instrument for energy use or pollution management. However, carbon taxes may bring about increases in the prices of energy and energy-intensive goods, and therefore hurt the poor of the society (Alton et al., 2014; Winkler & Marquard, 2011). Revenues generated from carbon tax can be used by a government in a progressive manner, a manner that encourages the sustainable use of energy and offset the potential effects of higher energy prices on the poor.

f. *Carbon tax is not yet popular in the tax regime of Zambia.* However, if introduced at the point of production by developing states, it may encourage the sustainable exploration of minerals in a manner that is environmentally friendly and thus contribute to reducing activities that underlie emissions, resulting in climate change and attaining economic development. Hence, the use of carbon tax as an instrument to achieve sustainable extraction is important in Africa, because it can be useful in provoking a sustainable approach that reduces energy- and emissions-intensive mineral sectors of the economy and, therefore, protects the environment. Similar expectations can be made from initiatives such as the green economy and the implementation of a carbon tax, which are premised on reducing the negative impact of extractive activities on the environment. It is safe to assume that such initiatives can contribute to the protection of the environment.

g. *Strengthen the use of energy-efficient processes and technologies*: There are a number of challenges to the adoption of energy-efficient technologies in the extractive industries; for example, high capital and operating costs have contributed to limiting the uptake of energy-efficient technology. To overcome these barriers, economic incentives, including tax rebates, tax credits and grants, could mitigate or reduce the upfront costs of efficient technologies. Reforming investment incentives also provides an opportunity to attract those investors using the best available technologies. In addition, fossil fuel subsidies must be reformed to improve the economic viability of energy-efficiency innovations (Sayeh, 2014).

h. *A robust regulatory framework is another avenue:* that can be used to improve the uptake of efficiency standards. Industry-wide standards for the emission-intensity of mining products and processes could bring the industry up to a minimum level in line with international standards (Cole, 2011). There is a need for setting up measuring and reporting requirements for mining companies that are important complements to energy efficiency standards, providing the ability to collect data and review companies' compliance with regulatory standards. While large mining and other extractive operators will have the resources to comply with reporting measures, it is important to consider the specific needs of artisanal miners with fewer human and financial resources, which could act as a barrier to the successful implementation of this regulatory tool.

i. *Switch to lower carbon and renewable energy sources*: There should be a move towards the use and expansion of natural-gas production as a cleaner fossil-fuel alternative. Natural gas could be used to power large-scale industrial projects while generating fewer GHG emissions than alternative fossil fuels (Banerjee et al., 2014). In addition, new gas developments could be a source of fiscal revenue for the governments of Southern Africa and, if managed effectively, it is possible these revenues could support the development of a low-carbon transition, including, for example, the expansion of renewable energy (Greene & Lemma, 2015). Thus, a consideration for the increased domestic production and use of any fossil fuels, including natural gas, must be alongside incentives for renewables and energy-efficiency measures.

Conclusions

Academic analysis of climate change and the extractive sector has treated the subjects as though they were path-independent. This paper sets out to explore the link of climate change to the extractive industry and the implication of this link for the protection of the environment and the economy in Southern Africa. It established that the link between climate change and the extractive sector can be both negative and positive. Climate change can negatively impact the inputs of water and energy, people, supply chains, markets, exploration, construction, operation, closure and post-closure aspects of the extractive sector in Africa. Also, as demonstrated in the paper, the nexus of climate change and the extractive industry can bring about environmental harm in that unsustainable extractive processes in terms of its outcome of deforestation and energy use are a significant source of carbon emission contributing to global warming.

The paper has also established positive implications in the above link, in that the relationship between the themes can stimulate initiatives that could contribute to a sustainable extractive sector. The sector enhances the economy and reduces the emissions that contribute to climate change. These projects can reduce the reliance on the extractive sector and thereby guarantee sustainable use, which can positively impact the environment and economic development.

Other initiatives capable of similar implications for the extractive sector are the green economy, which enhances natural-resource efficiency, and carbon tax, which could address emissions associated with the extractive sector in Africa. In the light of the foregoing discussion, the link of climate change to the extractive sector and its implications should be taken into consideration in the policy direction of states in Africa.

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8

The Implications of Climate Change for Artisanal and Small-scale Mining in the SADC Region: The Case of Gold in Tanzania

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Abstract

This research paper provides an assessment of the implications of climate change on the ASM sector in the SADC region. It uses the ASGM sector in Tanzania as a case study. The research objectives were to map the direct and indirect impacts of climate change on ASGM activities, develop projections of how climate change will influence the working hours and job losses in the ASGM sector, identify potential adaptation strategies, and make policy recommendations on the integration of climate change and ASM considerations into existing instruments. The research was conducted through a desktop study and relied on secondary data available in the literature. Several interviews and consultation meetings were conducted with stakeholders in the ASM sector in Tanzania to validate the data and to obtain additional information on the ASM sector and climate change. The research established that climate-induced hazards have the potential to eradicate the role of ASM as a safety net to vulnerable communities. There are measures that can be put in place to reduce the consequences of ASGM activities and to safeguard the livelihoods of hosting communities. At a policy level, climate change and ASM issues should be integrated into existing policy frameworks and interventions.

Introduction

Background and context

Despite the declining share of global gross domestic product (GDP), the total production output for extractive industries has been increasing (Bourgouin, 2014), as reflected in the amount of GHG produced by these industries. According to the IPCC (Edenhofer et al., 2014), the total GHG emissions from the extractive sector almost doubled between 1970 and 2010. At present, extractive industries account for 50 percent of all carbon emissions (UNEP, 2020). With the demand for industrial products expected to continue increasing, the percentage contribution of extractive industries to GHG is expected to reach even higher levels.

Since the initiation of the Paris Agreement in 2015, there has been growing attention on mitigation strategies to facilitate the reduction of GHG emissions and the transition of industrial activities to a low-carbon future. This is in line with the Sustainable Development Goals (SDGs), specifically SDG 13, which aims to combat climate change and its consequences. The extractive industries are expected to play a significant role in both reducing the magnitude of climate change and lessening the consequences of climate-induced hazards on its viability and contribution to broad-based socio-economic development.

According to Ruttinger and Sharma (2016), the viability of extractive industries is dependent on the extent to which their activities can mitigate and adapt to the impacts of climate change. Pearce et al. (2010) also submit that the long-term sustainability of operations and their contribution to social development depend on their ability to mitigate the impacts of climate change. More broadly, climate change risks in mining operations are tied to sustainable development priorities that influence the social licence to operate, and these include local community engagement, social development, biodiversity enhancement, the protection of sensitive environments and natural resource stewardship (ICMM, 2013).

Climate change is also important to the extractives sector because most operations are located in climate-sensitive environments where access to water and energy is constrained (ICMM, 2013). This means that most operations will be vulnerable to climate change because of their dependency on natural resources and ecosystem services for inputs into activities and processes (i.e., mining operations require ecosystem services for operations, for example, a habitable climate, access to water resources and access to land) (Pearce et al., 2010). Giving examples of operations located in climate-sensitive areas (Mongolia's Gobi Desert, Atacama in Chile and Pilbara in Western Australia), Rüttinger and Sharma (2016) highlight that the impact of climate change on mining operations will be severe in both magnitude and coverage. This is based on the evidence from the world's leading mining regions where extreme weather events and natural disasters had devastating impacts on operations (Rüttinger & Sharma, 2016; Aleke & Nhamo, 2016).

Ruttinger and Sharma (2016) categorise the impacts of climate change on mining operations as direct and indirect. The direct impacts include consequences that affect the core activities of an operation. The indirect impacts are linked to the disruption of supply chains and networks that mining operations depend on across the value chain. Broadly, the impacts on the core operations include physical risks to assets and infrastructure, supply chain risks from the disruption of transport networks, and increased competition for natural resources such as water and energy (ICMM, 2013). The other impacts include employee health and safety adversely affected by increases in diseases and exposure to heat-related illnesses and the likelihood of accidents related to rising temperatures, increased physical and non-physical risks making project financing difficult to obtain, and threats to the social licence to operate, with increased competition for resources between companies and communities (Nelson & Schuchard, 2009).

According to Rüttinger and Sharma (2016), the impacts of climate change on mining operations are susceptible to "cross-fertilisation", resulting in newer and complex second-order impacts. The level of risk is influenced by the interaction between operations and communities. Some of the risks that will have indirect consequences to mining operations from communities include impacts on human health, water availability, impacts on agriculture, workforce availability and social conflicts (ICMM, 2013). Essentially, the impacts of climate change on mining operations extends beyond the core activities of mining operations and will affect supply chains and networks, communities and the broad-based socio-economic development priorities of countries dependent on the exploitation of minerals.

According to Jegede (2016), the consequences of climate change are expected to be severe in Africa because of the dependence of most countries on mineral resources for development. Climate change risks will also be exacerbated by multiple stressors, such as poverty, unemployment, food security, HIV/AIDS and other socio-economic ills, which are prevalent in most African countries. Accordingly, the impacts of climate change are expected to spill over to socio-economic priorities through the negative impacts on key sectors of the economy, including agriculture and mining. The FAO (2009) estimates that agriculture losses across the continent by 2100 will amount to 2-7 percent of GDP in parts of the Sahara, 2-4 percent in western and central Africa, and 0.4-1.3 percent in Southern Africa. The sub-Saharan region is expected to surpass Asia as the most food-insecure region in the world (FAO, 2009). With water scarcity expected to worsen, the productivity of mining operations on the continent will be adversely impacted, resulting in risks of retrenchments and the failure of mining operators to meet their socio-economic development responsibilities.

While the attention on climate change and mining has increased over the years, the scope of work has not been extended to understanding the implications of climate-induced hazards on the artisanal and small-scale mining (ASM) sector. This is despite the recognition of the potential role of the sector to broad-based socio-economic development, particularly in rural areas. To this end, Africa has much work to do as far as the issues of climate change and ASM are concerned, from both a challenges and opportunities perspective. This is particularly important because of the continent's high dependency on livelihoods from ASM, as the sector employs approximately 9 million people across the continent.

While climate change poses risks to mining operations, the transition to the low-carbon economy offers opportunities for growth and sustainability. Such opportunities include those arising from the push towards clean, green and renewable energy technologies necessitating the production of certain minerals. According to Sovacool et al. (2020), climate change adaptation will create new natural resources and supply chain opportunities because substantial raw materials will be required to build new low-carbon devices and infrastructure. These minerals include cobalt, copper, lithium, cadmium, and rare earth elements (REEs) which are needed for technologies such as solar photovoltaics, batteries, electric vehicle (EV) motors, wind turbines, fuel cells and nuclear reactors (Sovacool et al., 2020). Some of these minerals are currently being exploited by ASM operators, such as cobalt in the Democratic Republic of Congo (DRC).

Understanding the nexus between ASM and climate change is also important because of the evident relationship between the ASM and agricultural activities. An increasing number of studies have found that there exists a complementary relationship between ASM and agriculture. It is therefore imperative that African governments understand the implications of climate change more holistically and take a considered approach to the impacts that climate change is going to have on all sectors of their economies, including ASM.

The result of a desktop study supported by key informant interviews, this research explores the nexus between ASM and climate change using the artisanal and small-scale gold mining (ASGM) sector in Tanzania as a case. At the core of this research paper is the development of a model to understand how climate change is going to impact the ASGM sector in the future, from both a positive and negative perspective. The paper also identifies policy implications and also posits possible adaptation strategies for the ASM sector.

Problem statement

During the literature search for the paper, only two publications were found on ASM and climate change. The first paper was a policy brief on ASM and climate change prepared by the African Minerals Development Centre (AMDC) in 2017 (AMDC, 2017). The policy brief highlighted the importance of climate change considerations in ASM formalisation policy. The second paper was a sector environmental guideline on ASM, which discussed the environmental impacts of ASM, including the impact on climate change. It also mapped the direct and indirect impacts of climate change stressors on ASM activities and identified potential adaptation strategies for the sector. The paper was part of the USAID's Global Environmental Management Support and was published in 2017 (USAID, 2017). Besides the two papers, there were no initiatives focusing on climate change and ASM and no research studies that mapped the vulnerabilities of ASM to climate change.

In view of the dearth of research on the topic, this research report aims to increase the understanding of the impacts of climate change on the ASM sector by focusing on ASGM, which accounts about 50 percent of the total workforce in ASM (Seccatore et al., 2014). The report maps the vulnerabilities of the ASGM sector to climate change in Southern Africa and presents a model for estimating the impacts of climate-induced job losses in ASM. The report also discusses policy implications on both ASM and formalisation efforts and provides adaptation strategies that can be considered to address the issues and consequences of climate change on ASM. The research was conducted with the aim of reinforcing the sector's resilience and adaptive capacity to climate change risks and natural disasters in Southern African economies, which feeds into SDG 13 and specifically targets 13.1 (UN, 2015).

Research objectives

Using the ASGM sector of Tanzania as a case study, the paper aims to:

- Map the direct and indirect impacts of climate change on ASM activities, which includes the impacts of climate change on core activities, ASM supply chains and the broader network.
- Develop projections of how climate change will influence the working hours of the ASGM sector.
- Develop a framework to assist governments and other stakeholders assess the vulnerability of existing ASM policies to climate change mitigation and adaptation.

Methodology

The research was conducted through a desktop study and interviews with a few selected stakeholders in the ASM and environmental management sectors in Tanzania. The broad framework for the research consisted of a literature review, data collection, data analysis, and framework development. The components of the methodology are elaborated on below as follows:

- *Literature review*: The review consisted of papers from refereed journals, conference papers and grey literature. It collected broad information on climate change and the extractive sector and specific information on the climatic conditions of Tanzania as well as information on the country's ASM and ASGM activities.
- *Data collection*: Both primary and secondary data were collected for the research. The secondary data were collected from the literature review. The type of data collected included estimates of ASM activities with respect

to employment numbers and commodities exploited with a specific focus on ASGM. Data on climate-induced job loss were collected from the ILO (International Labour Organization) and similar sources (ILO, 2019). Data from the wider ASM literature and the diversified/alternative livelihoods literature that analyses the drivers or push factors that cause individuals to pursue ASM (Hilson & Garforth, 2012) were also collected. The primary data were collected from interviews and consultations with various stakeholders in the ASM sector in Tanzania.

- *Data analysis and framework development*: Analysis of the qualitative and quantitative data collected aimed to shed light on future trends and projections of ASM activities and assess the vulnerability of the sector to climate change. The frameworks used were adopted from existing models; for example, the ICMM's framework for assessing the impacts of climate change on the mining sector was used to map the on-site and off-site impacts of a changing climate on ASGM. The ILO's methodology was used to estimate climate-induced job loss in industries such as agriculture and construction and was used to model future job losses in the ASGM sector. The findings from the data analysis were used to identify potential adaptation strategies and to inform recommendations on policy formulation and responses on ASM and climate change.

The ASM and climate change nexus

a. Understanding ASM and the case of ASGM in Tanzania

ASM is currently understood to be "all mining and mineral processing activities that are carried out using basic methods with limited inputs (i.e., capital, technology and equipment, etc.)" (Mutemeri et al., 2016). ASM exploits precious and semi-precious minerals, base metals, and industrial minerals and construction materials. An estimated 20 percent of the global output of gold and diamonds are produced by the ASM sector (IGF, 2017). In Africa, the sector is largely informal (unlicensed, with minimal regulatory compliance), even though most mining regimes provide for some form of ASM licensing (Ledwaba & Mutemeri, 2017). Though associated with negative social, health and environmental impacts, the sector has grown to become an integral part of local economies, providing supplementary income and sometimes the only livelihood for many poor communities, with an estimated 2.5 million people engaging in ASM in the SADC region (IGF, 2017).

Tanzania's ASGM sector: The number of people participating in the ASM sector in Tanzania is difficult to ascertain with confidence. The last baseline survey found was 2012 carried out by the Ministry of Energy and Mines and estimates that 688,385 miners operate in the ASM sector (just under 30% are women). A more recent study, commissioned by the Institute for International Economic Development (IIED), estimates 1.5 million miners in the sector, with 9 million reportedly depending on it for their livelihoods (Hilson, 2016). The sector exploits various commodities, such as gold, tanzanite, diamonds, industrial minerals and construction materials (these include clay, sand, dimension stone, and aggregate). Another study estimates the ASGM sector in Tanzania has 690,000 people (AGENDA, 2015). The participation of children is also documented and reported to be common in some areas. The ASGM sector was the only producer of gold in Tanzania until the early 1990s when the government introduced a new mining regime to attract foreign direct investment (FDI).

Most of the ASM gold mining operations are located in the greenstone belt around Lake Victoria in the Geita, Shinyanga and Mara regions. Some occurrences of gold are also found in the Morogoro region, which is located in the eastern part of the country, as well as in the coastal region of Tanga. Figure 8.1 shows the mineral map of Tanzania and ASM sites. The yellow boxes indicate the concurrence of precious metals (mostly gold); this is where ASGM is found.

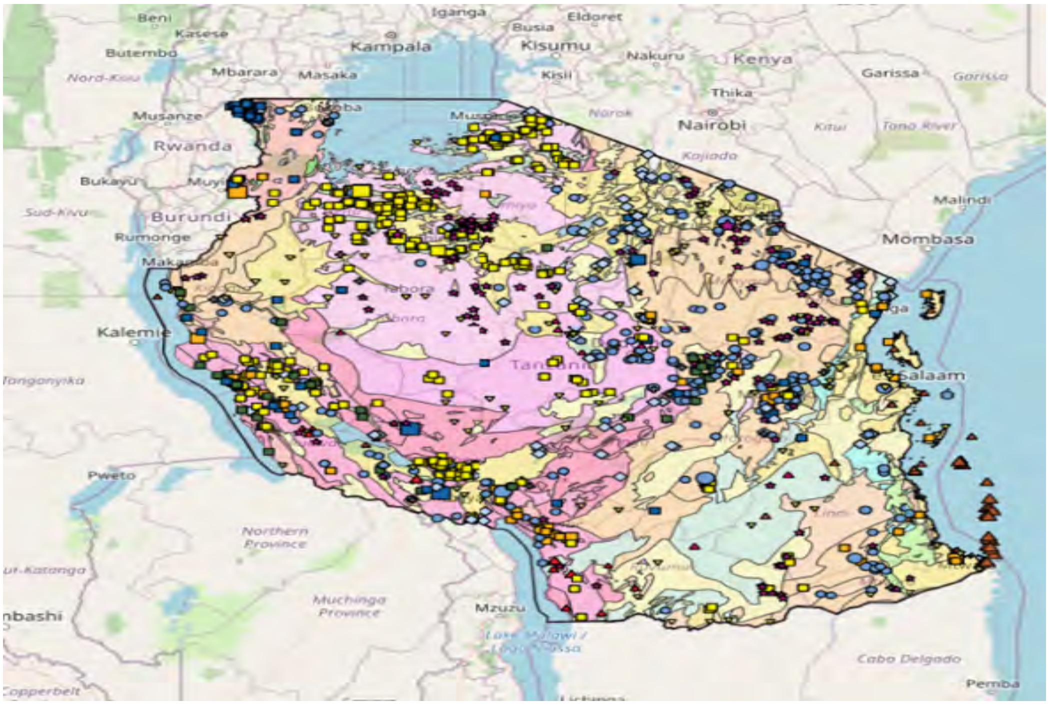

Fig 8.1**:* Mineral map of Tanzania. (Source:** Geological Survey of Tanzania, Geological and Mineral Information System. Accessed July 2020. Available at: https://www.gmis-tanzania.com/.)*

Minerals extracted from the Tanzania Mining Cadastre portal, showing the location of ASM centres (black dots). These are located in areas with a high concentration of primary mining licences (PML) for ASM.

AGSM in Tanzania and its interface with climate change

The objective of this sub-section is to provide details on the ASGM value chain and activities as well as the environment in which the subsector operates, highlighting the relevance (if any) to climate change. It explores the main functions of the ASGM sector, namely regulation, exploration, mining, processing, beneficiation and value addition, transportation of product and inputs, marketing and distribution and support services.

1. *Regulation*: The main law applied to the ASM sector in Tanzania is the Mining Act (14/2010) and its attendant amendments. Other relevant laws include the Land Act, the Environmental Management Act and the regulations under the finance and trade laws. These legal instruments cover the following areas:

licensing and operating practices in exploration; mining processing; and buying and selling (including export). The main issues of concern with respect to operational practices are environmental management, occupational health safety, labour practices and land access (i.e., surface rights). Amendments in the Mining Act of 2010, which resulted in the cancellation of retention licences, caused a release of a substantial amount of land by large-scale miners (LSMs), and this land became available for ASM. Figure 8.2 provides data on mineral licences issued in Tanzania from 1973 to 2020.

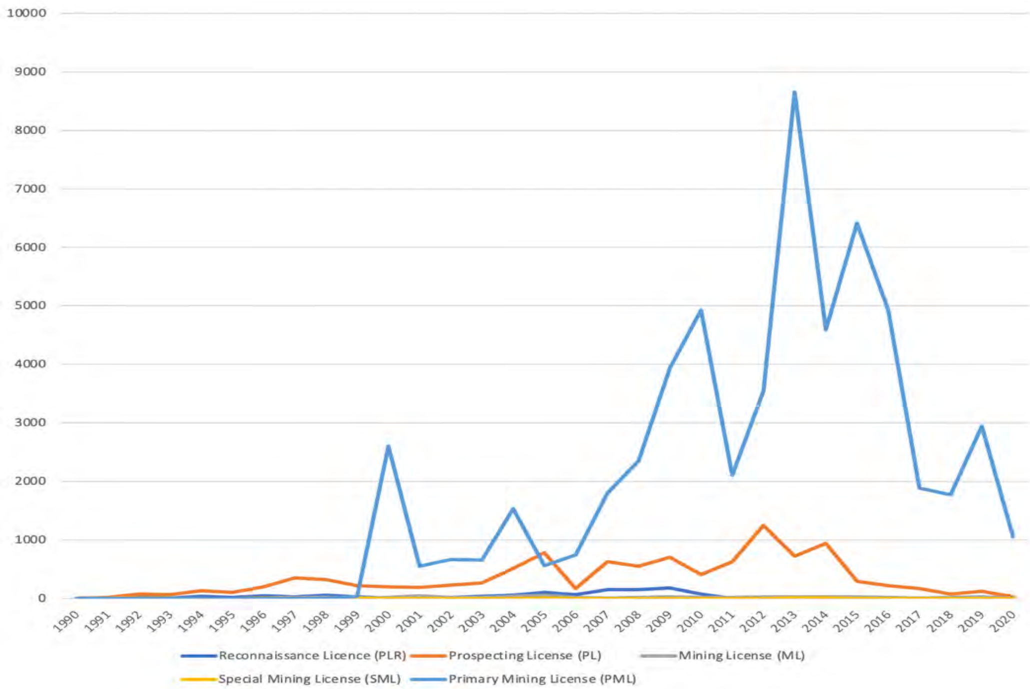

Fig 8.2. Data on mineral licences issued in Tanzania from 1973-2020. (**Source:** *Mutagwaba, W, Bosco Tindyebwa, J, Makanta, V, Kaballega, D and Maeda, G (2018) Artisanal and small-scale mining in Tanzania – Evidence to inform an 'action dialogue.')*

ASGM operations are provided for in the law through a special category of licence referred to as the primary mining licence (PML), which is intended for operations where the capital investment is less than USD 100,000. The number of PMLs issued has fluctuated over the years; in 2018, 2019 and 2020 there were 1,172,941 and 1,053 licences, respectively. The PML is issued to Tanzanian nationals only. There are no area restrictions; the PML is valid for seven years and it is renewable indefinitely. PMLs also come with obligations for good environmental management and occupational health and safety (OHS) practices. There are, however, restrictions on the issuance of mining licences over forest reserves; full environmental impact assessment (EIA) and attendant environmental management plan (EMP) are required.

The main authority responsible for the sector is the Ministry of Mines. However, the administration of the sector was recently changed to fall under a newly formed autonomous Mining Commission with regional resident mine offices and a Small-Scale Directorate. Gold buying centres were instituted in 2019 through the Ministry of Finance.

Apparently, there is an element of self-regulation through industry bodies that include regional associations such as Geita Regional Miners Association (GEREMA) and national associations such as the Federation of Miners Associations of Tanzania (FEMATA) and, for ASM, the Tanzania Women in Mining Association (TAWOMA) and the Tanzania Chamber of Minerals.

1. *Relevance to climate change*: No specific provisions are made for climate change in the country's ASGM regulatory framework. However, the obligation to manage environmental impacts may result in obligations to reduce the contribution of ASGM activities on climate change by lessening the impacts of the operations on deforestation and sensitive environments. Based on the available estimates, the size of the ASM sector has apparently increased as confirmed by the increasing number of licences issued to ASM operators and facilitated by the recent changes in mining laws and institutional arrangements.

   Gold production from the ASGM sector has also increased (as indicated through personal communication with a Tanzanian ASM expert, Willison Mutagwaba). While these developments are positive and may lead to an increased role of ASGM in local economic development, this in turn may result in greater impacts on the environment, some of which may contribute to climate change.

2. *Exploration*: The common practice in exploration is to combine it with exploitation/mining, and this is particularly true for the artisanal end of the sector where rudimentary methods, such as using basic equipment, are

applied. Mineral exploration in ASGM is predominantly done by the miners themselves. In addition, the Tanzania Geological Survey also plays a role in providing geological information for the more advanced and better-resourced operators. The state mining company STAMICO also plays a role by providing drilling equipment as do other companies that provide drilling services to this size of operation. The main activities during exploration include the clearing of land and vegetation, and excavations to collect samples for evaluation.

Relevance to climate change: Environmental impacts resulting from exploration include deforestation, which has negative impacts on biodiversity and ecosystem services. It also affects climate change mitigation by removing carbon sinks (Amazon Aid Foundation, 2019). Desperation regarding livelihoods may result in ASGM miners encroaching on protected areas like forests and game reserves. Hence the actors performing these activities are an important consideration for the climate change agenda.

3. *Mining:* As previously mentioned, mining in ASGM is often undertaken in parallel with exploration and not as a distinct phase in mine development, as observed in LSM. Depending on the type of deposit, it may be underground mining or open pit. The ore type may be hard rock, eluvial and alluvial stream sediments. Mining sites commonly exhibit large-scale degradation due to deforestation, haphazard digging without backfilling of mining pits and the indiscriminate disposal of mining waste. The ASM operators themselves do the mining. However, certain common practices include tributing where the individual or entity licensed by the government to operate allows informal miners to work on the licensed area and then share the output. Miners also illegally get gold-bearing material from LSM operations by hand-cobbing (visual sorting) waste rock and taking tailings material from tailings storage facilities (TSFs).

   Relevance to climate change: The deforestation observed from ASGM in Tanzania has direct impacts on climate change, as forests are carbon sinks. Another impact of ASGM on the environment that can be linked to climate change is siltation resulting from the discharge of tailings into natural water courses. Linked to this would be the destruction of riverbanks and diversion of river courses from the exploitation of alluvial river sediments as a source of gold. The underground shafts of ASGM are frequently poorly ventilated and therefore working conditions may be affected by rising temperatures. The poor design of ASGM open pits and shafts may result in flooding, which can reduce the productivity of the operations during high rainfall events. Also, not all ASGM operators can afford dewatering pumps. Though emitted in small amounts, toxic fumes released from vehicles or machinery contribute to climate change.

4. *Processing:* Mineral processing to extract the gold in the ASGM sector in Tanzania is done using a range of methods with varying levels of mechanisation. Sometimes, mercury amalgamation is used for final extraction (open burning of mercury is reportedly common, posing serious environmental and health hazards from the releases and emissions). Depending on the type of ore, processing may also involve cyanidation of tailings sourced from less efficient operations of gravity separation. Another ASGM practice that can have environmental impacts is the burning of ore boulders to aid crushing. The resulting fumes may include sulphurous gases if the ore contains sulphide, which is a common occurrence in hard-rock gold ore.

   The processing of gold ore is done by the miners themselves. However, as with mining, this may be part of a tributing arrangement with a product-sharing arrangement. In addition, it is also common to use custom-processing centres that are mechanised where the miners take their ore to custom-processing centres and leave behind the tailings, which the centre owners may reprocess to recover the residual gold.

   Relevance to climate change: Siltation is an impact of ASGM on the environment that can be linked to climate change. It results from tailings discharged into natural water courses, which may in turn increase the risk of flooding during climate change induced high rainfall events. Also, processing uses a great deal of water, and the water scarcity that may result from climate-induced changes in precipitation would negatively impact the productivity of ASGM operations. Similarly, an increase in rainfall may cause flooding of the mine site.

5. *Beneficiation and value addition*: This involves the refining of the gold and also the production of finished products. Until recently there were no gold

refineries in Tanzania and any upgrading of the gold ore was done on a small scale by buyers and exporters. It is reported that the local jewellery industry also uses some of the locally produced gold for the local market. This is something encouraged by the government, and some interventions have been implemented that are particularly linked to the cutting and polishing of locally mined gemstones.

Relevance to climate: There are no obvious links to climate change, except potential for adaptation that is offered by livelihoods linked to producing value-added finished goods such as jewellery.

6. *Marketing*: The buying and selling of gold is managed through brokers and dealers' licences issued through the Mining Commission. The dealer licence category is meant for smaller national buyers and the broker licence is meant for larger buyers with the capacity to export. Gold produced by the ASGM sector can be bought and sold at local gold-buying centres that the government has set up throughout the gold-producing areas.

7. *Relevance to climate change*: There are no direct implications for climate change. However, a more formalised ASGM sector might result from the structured marketing of the gold. This may in turn result in improved environmental practices, with a possible reduction in activities such as deforestation that impact the climate. Similarly, the growth of viable ASGM operations may result in increased resilience to climate change impacts for concerned communities.

Table 8.1: Subsector analysis of ASGM in Tanzania and it maps the key stakeholders alongside their participation in the value chain and associated activities. ***(Source:*** *Mutagwaba, W, Bosco Tindyebwa, J, Makanta, V, Kaballega, D and Maeda, G (2018) Artisanal and small-scale mining in Tanzania – Evidence to inform an 'action dialogue.')*

		Participants											
		Policy makers, Regulators, Local authorities	LSM companies (like Acacia, Anglo Gold Ashanti, etc)	Legal ASM (holders of PMLs	Illegal miners (unlicensed sometimes encroach on LSM license areas)	Licensed processors (licensed to offer ore processing services to PML holders)	Illegal mineral traders	Industry Associations (for example, TCME, FEMATA, regional associations like GEREMA)	Local jewellers (promoted by government to add value locally)	Local buyers (holders of a dealer licence)	Foreign buyers (holders of a broker licence)	Service providers (inputs along the value chain)	Funders (includes both formal financial institutions, donors and informal financiers)
Functions	Regulation	X						x				x	
	Exploration		X	X	X							x	x
	Mining		x	X	X							x	x
	Processing		x	X	X	x						X	x
	Beneficiation value addition								X	x	X	x	x
	Transportation		x	x	x	x	x		x	x	x	X	
	Marketing and distribution		x	x	x	X	X		X	X	X	X	
	Support services	X	X			X	X	x				X	X

b. Understanding climate change and the case of Tanzania

Climate change stressors and country projections

Tanzania has a tropical climate that varies by region due to unique physical characteristics. The country boasts large lakes in the west and the north, and a topography that can vary from sea level to 1,600m in a single region. The coastal regions of the country are warm and humid most of the year (25˚C-17˚C), while the highland regions are more temperate (20˚C-23˚C) (McSweeney et al., 2006). Average annual temperatures in Tanzania have increased 1˚C since 1960.

Tanzania's rainfall patterns are mostly driven by the movement of the Inter-Tropical Convergence Zone (ITCZ); this zone is where the north-east and southeast trade winds converge. In this zone, the low pressure and heavy precipitation that characterise it migrate between the south and north of the country, causing bimodal rainfall patterns in some parts of the country (in the north and north-east) and a unimodal pattern in others (south-west, central, south and west). The country has observed a notable decrease in rainfall since 1960, recording a 2.8 mm rainfall decrease per month, per decade.

Extreme rainfall events are a key concern for Tanzania. In 2013, Tanzania informed the UNFCCC that more than 70 percent of its natural disasters are hydro-meteorological in nature. In 2008, extreme rainfall caused flooding, which displaced people and flooded mining pits causing over 70 fatalities (Tanzania, 2007). More recently, extreme rainfall events continue to be a problem with the north, west, central and southern parts of the country experiencing heavy and continuous rainfall in 2019 (TMA, 2019).

The wider impacts of climate change in Tanzania throughout this century are expected to be increased rainfall in most parts of the country and an increase in both minimum and maximum temperatures throughout most of the country (Luhunga et al., 2018). A recent study by Tanzania Meteorological Authority (TMA) in 2019 provided some of the most detailed projections of Tanzania's future climate. Using regional climate models (RCMs), the paper provided projections of daily rainfall and minimum and maximum temperatures under two representative concentration pathways (RCPs), RCP 8.5 and RCP 4.5, up until 2100 (TMA, 2019). The study found a clear warming trend (increased minimum and maximum temperatures) in the short (2011–2040), medium (2041–2070), and long term (2071–2100). The same report found that rainfall will increase between 0.25 and 1 mm per day in the north-east and coastal regions, while it will decrease in the west and south-western regions. The impacts of these trends will affect every part of Tanzania. Figure 8.3 shows the average minimum temperature in the country from the base period (1971-2000) to 2040, while Figure 8.4 illustrates precipitation in mm/day during the same period.

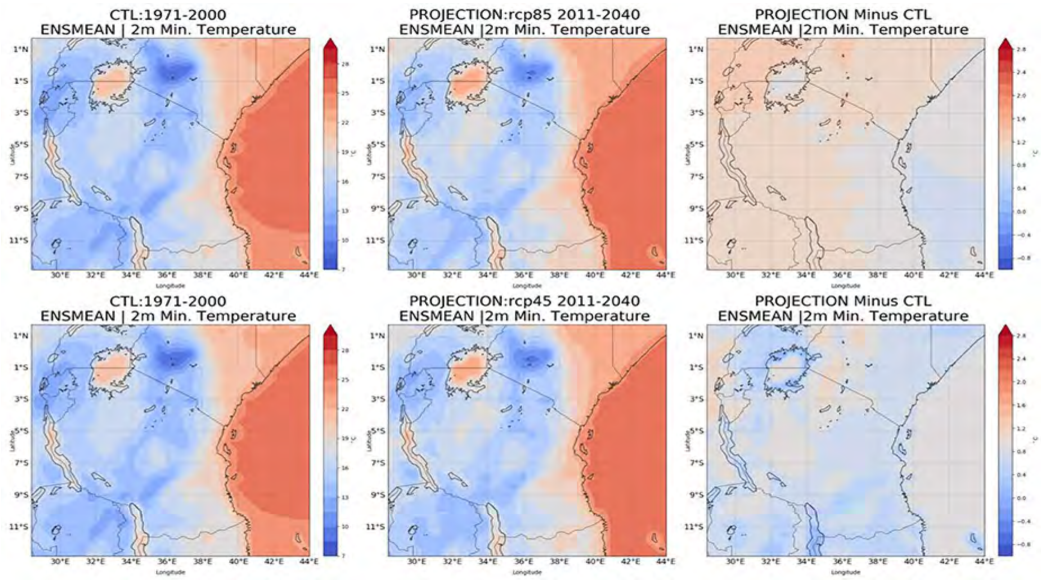

Fig 8.3. Average minimum temperature from base period (1971–2000) to 2040. (***Source****: Luhunga et. al. (2018))*.

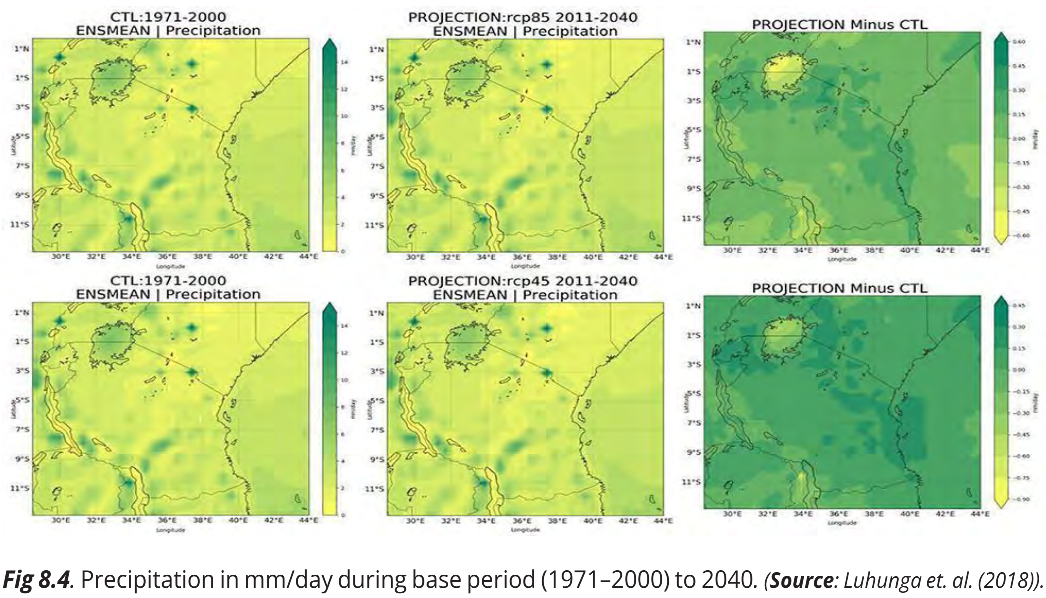

Fig 8.4. Precipitation in mm/day during base period (1971–2000) to 2040. *(****Source****: Luhunga et. al. (2018))*.

The structure of Tanzania's economy makes the country's economy and its people vulnerable to the impacts of climate change. The country has experienced relatively high GDP growth over the last decade, on average 6-7 percent per year (The World Bank Group. 2019). Despite this strong growth, the economy is still heavily dependent on agriculture, as this sector accounts "for a quarter of total GDP and two-thirds of jobs" (World Bank, 2019). The projected impacts of climate change on agriculture in Tanzania are expected to be severe, with long-term implications for planning, resource allocation, employment patterns, pesticide use, crops and seed selection (Irish Aid, 2015). With regards to employment patterns, climate change will cause significant job losses in the sector. The ILO estimates that, in 2030, Tanzania's agricultural sector will lose 1.12% of all working hours to heat stress (ILO, 2019).

It is projected that the other labour-intensive sectors of Tanzania's economy will be impacted similarly by the effects of climate change-induced job loss. The ILO provides the following estimates for working hours lost due to heat stress in Tanzania in 2030; industry will lose 0.36 percent of job hours; construction will lose 1.12 percent and services will lose 0.02 percent (TMA, 2019). Including the losses for agriculture, the ILO estimates that a total of 303 000 full-time jobs will be lost due to heat stress in 2030.

Climate adaptation plans

Tanzania is aware of many of its vulnerabilities to climate change and has worked for over a decade to improve its resilience through strategic policy decisions. The Vice President's Office – Division of Environment (VPO-DoE) is the lead institution for coordinating climate change and environmental issues. In 2007, this office published the country's National Adaptation Programme of Action (Tanzania, 2007). This document set out to identify the areas of most urgent concern and promote the activities best suited to help various sectors adapt to the impacts of climate change. The plan ultimately outlined 14 priority adaptation projects in a variety of sectors. This early effort at national adaptation planning would soon be followed by larger and more ambitious policy initiatives.

In 2012, Tanzania completed its national climate change strategy. This document was informed by an extensive situational analysis and made detailed recommendations on strategic adaptation and mitigation activities across numerous sectors (Tanzania, 2012). The country has also developed topical and geographically focused adaptation strategies and completed its Climate Change Adaptation Plans for Water in 2012 and Agriculture in 2014 and the Zanzibar Climate Change Strategy in 2014 (Leiter & Sudi, , 2017). These adaptation plans are narrower in focus but provide greater detail on the country's adaptation requirements and plans in the areas of water, agriculture and plans unique to its archipelago due to the adaptation needs of islands.

The agricultural- and water-related plans are of particular relevance to Tanzania's ASM sector because ASM workers often come from agriculture (either to supplement income or create new livelihoods), due to the tensions that arise over land use. As one key informant detailed during an interview, "Small-scale mining is done in areas mostly used by smallholder farmers for small-scale irrigation". The interviewee explained that this results in the disruption of local-level coping strategies of smallholder farmers that were instituted as part of Tanzania's Climate-Smart Agriculture (CSA) plan. In turn, ASM miners attempting to use these areas are hindered by the smallholder farmers. The tension over land use between these parties is a difficult problem and not unique to Tanzania (ACET. 2017).

In 2015, Tanzania submitted its climate targets to the UNFCCC, the Intended Nationally Determined Contributions (INDCs), which were created as part of the UNFCCC's Paris Agreement, and are a country's publicly outlined post-2020 climate actions. For a country with as limited a carbon footprint as Tanzania, these climate actions are less focused on mitigation activities and emphasise sustainability and adaptation efforts in numerous sectors (particularly agriculture and water resources) (Tanzania, 2015).

Tanzania is currently in the process of developing its National Adaptation Plan (NAP), a process for identifying medium and long-term adaptation needs and developing the strategies, programmes, policies and proposals required to address those needs. The VPO-DoE, with assistance from Germany's GIZ and the United States Agency for International Development (USAID), is currently conducting this consultative process. This rigorous process will yield not only plans but also provide the platform for the country to access international climate finance to assist with the execution of the plans outlined in the NAP (see appendix section of this paper for a more comprehensive outline of Tanzania's adaptation efforts).

Impacts of climate change on ASGM Tanzania

Table 8.2 maps the potential impacts of a changing climate on ASGM in Tanzania. The framework used brings together four areas, namely the climatic stressors, the secondary effects, direct impacts on ASGM operations, and broader impacts on communities, supply chains and other sectors of the economy. The analysis is based on projected climate impacts in Tanzania, with stressors and variables categorised into projected temperature increases and increases and decreases in precipitation. These primary stressors and variables result in indirect or secondary stressors. Given the understanding of the characteristics of ASGM in Tanzania, one is able to estimate the on-site and off-site climate change impacts. The on-site impacts are consequences of the core activities of ASGM operations, and the off-site impacts include the broader effects on communities, supply chains and other sectors of the economy.

Table 8.2. Climate change's negative impacts on ASGM in Tanzania. (***Sources: I****CMM, 2013 and Luhunga et. al., 2018)*

Stressor / variable	Indirect or secondary stressor	Potential CC impacts on-site	Potential CC impacts off-site
TEMPERATURE INCREASES: Increased minimum and maximum temperature trends over the entire country projected until the end of the century	• Increased temperatures will limit the amount of physically intensive work that can be performed • Increased temperatures are expected to reduce the length of growing season for some crops and encourage disease and pest eruption	• Fewer daytime working hours leading to lost jobs on-site • Lower productivity of workers because of heat stress and related lower energy levels • Inability to access some underground workings where the ventilation and cooling is poor • Poor underground support because of difficulties in accessing underground timber support (timber lost in forest fires). This may cause accidents and fatalities in ASM sites.	• Loss of livelihoods for people dependent on mining • Loss of livelihoods for people dependent on smallholder farming because of poor soil conditions • Loss of jobs from LSM because of higher operating costs

Stressor / variable	Indirect or secondary stressor	Potential CC impacts on-site	Potential CC impacts off-site
	• Increased temperatures may result in decreased soil moisture which would affect runoff and river flows • Increased risk of wildfires • Increased temperature may result in rising evaporation rates affecting water availability (ICMM, 2013)	• Changes in shifts with working hours pushed to night-time and this may lead to accidents because lack of resources to operate at night (i.e., adequate lighting) • Pressure to access new shallower deposits posing a risk to protected areas • Employee health may be compromised because of heat-related diseases and vector-borne diseases	• Loss of jobs and livelihoods will push people into informal ASGM
RAINFALL INCREASE: Most parts of the country are likely to feature increased rainfalls during the current century in the range of 0.15 to 0.6 mm/day. In the north-eastern highlands and coastal regions, rain is projected to increase in the range of 0.5 to 1 mm/day and 0.25 to 0.5 mm/day.	• Increased rainfall could increase risks of flooding in some areas. • Increased rainfall may lead to increased soil erosion which cause the deposition of soil in rivers (i.e., siltation and sedimentation) • Increased rainfall may lead to mudslides	• Flooding of open pits and underground shafts, thereby limiting access • Damage to tailings storage facilities and settling ponds • Development of acid mine drainage and pollution of underground and surface water systems • Damage to mine infrastructure leading to a loss of operations • Increase in waterborne diseases, decreasing productivity of workers	• Damage to public infrastructure like roads, bridges, power lines, etc., leading to lost operating hours and less viable ASGM operations • This will also affect both upstream and downstream activities • This may also lead to displacement of communities because of a loss of land

Stressor / variable	Indirect or secondary stressor	Potential CC impacts on-site	Potential CC impacts off-site
		• Increase in operating costs, for example, dewatering equipment will be required to drain water out of working areas	• Increase in the number of informal/ illegal miners due to push factors (a loss of agricultural livelihoods because of flooding)
RAINFALL DECREASE: The western regions, south-western highlands and eastern side of Lake Nyasa are likely to experience decreased amount of rainfall in the range of 0.5 to 1mm/day in the medium-term (2041–2070)	• Changes in availability of water sources (i.e., increased drought conditions) • Reduced access to fresh water • Drought may affect the water quality	• Reduced business viability because of a scarcity of water for running mining operations, particularly processing • Poor water sanitation and hygiene conditions because of limited access to water • Employees health may be affected because of access to clean water	• Increase in numbers of informal/ illegal miners due to a loss of agricultural livelihoods because of drought conditions • Increase in competition for water resources resulting in conflicts between ASGM and community members (i.e., farmers) • Drought conditions can exacerbate food insecurity because of poor crop production

Stressor / variable	Indirect or secondary stressor	Potential CC impacts on-site	Potential CC impacts off-site
			• The health of communities may be compromised because of vector-borne diseases and illnesses from poor hygiene environments • In-migration can be expected to include foreigners from neighbouring countries due to porous national borders. This could result in increased pressure on social services.

Modelling the future impacts of climate change on ASGM in Tanzania

Estimating climate change-induced job losses in Tanzania's gold sector

Part of the contribution of this paper is providing estimates of the impact of climate change on jobs in Tanzania's ASGM sector. As previously mentioned, this subsector is estimated to directly employ approximately 690,000 people across the country. The average gold miner and processor in Tanzania earns USD 82-110 per month (this is more than double the average wage for similar roles in agriculture) and the sector supports more than 3 million people (using the multiplier of 4.9 based on the average size of a household). The number of people dependent on ASGM constitutes 5 percent of the total population, thus making ASGM workers significant contributors to Tanzania's economy (Merket, 2019). This section of the report estimates the number of hours of lost productivity that will occur in Tanzania's ASGM sector as a result of workers being unable to work in conditions of increased heat. These lost hours translate to lost jobs and ultimately lost economic output for a sector that contributes considerably to the country's economy. These estimates should provide policymakers with a better understanding of the significant impacts that climate change presents to the ASGM community in the relatively short-term and should serve as the basis for appropriate interventions.

Methodology

The estimated impact of climate change on jobs in the ASGM sector is determined by building on the methodology that the ILO has used in the past to estimate climate-induced job losses in other industries, such as agriculture and construction (ILO, 2019). This methodology focuses on the impact of heat stress on labour productivity; the model is built on epidemiological evidence on the impact of heat stress on the capacity to work. Flouris et al. (2018) provide a meta-analysis on the subject. By combining the temperature projections from climate models with labour-force estimates and health data, the method allows for an estimation of how much productivity will be lost in a particular sector due to heat stress. This methodology is extended for use in this paper because it allows the study to estimate the impact of heat stress on the productivity of Tanzania's ASGM sector without having to perform the entire modelling exercise from scratch. The steps used by the ILO and this study to generate these estimates are explained in brief in Table 8.3.

Table 8.3. Summary of analytical steps. (***Sources:*** *Flouris, A. et. al., 2018 and ILO, 2019.)*

Step	Input data	Output
1. Selection of climate data	(a) Historical monthly data on temperature, humidity and wind speed (1981–2010); (b) Future modelled increase in the data (2011–2099) for the 1.5°C warming scenario.	Temperatures (Tmax, Tmin, Tmean), relative humidity and wind speed for small geographical areas (grid cells) covering 50 km x 50 km at the equator.
2. Derivation of monthly heat stress index wet bulb globe temperature (WBGT)	(a) Climate data selected in step 1. (b) The data for the historical period 1981–2010 were labelled "1995" (midpoint). The "2030" data were produced from model data for 2011–2040 and adjusted from the midpoint 2025 to 2030.	Multi-year monthly value of the heat stress index (WBGT) for the historical data; Daily distributions of heat stress index (WBGT) (maximum and mean) for the projected data.
3. Estimation of hourly heat stress index (WBGT) distributions	(a) Monthly values of heat stress index (WBGT) for historical data (derived in step 2); (b) Monthly mean of daily values of heat stress index (WBGT) (maximum and mean) (derived using daily values from step 2).	Number of hours per month with standardised temperatures (WBGT) between 20°C and 50°C.
4. Estimation of employment data by applying national estimates of employment-to-population ratios for employment sectors to population data for that area	(a) National estimates of employment-to-population ratio (ages 15+) for four sectors: agriculture, construction, industry and services; (b) Population data (ages 15+) for each small geographical area.	Share of employment (ages 15+) in each of the four sectors for each small geographical area.

Step	Input data	Output
5. Derivation of relationship between heat exposure and physiological response	(a) Quantitative data from epidemiological studies on the impacts of heat stress on work capacity; (b) ISO 7243 guidelines on work intensity levels at various metabolic rates.	Smooth functions that relate heat stress index (WBGT) to expected work capacity loss for three levels of physical work intensity (200 W, 300 W, 400 W).
6. Calculation of working hours lost per worker for each level of physical intensity in each small geographical area	(a) Gridded heat stress (WBGT) exposure data (derived in step 3); (b) Three exposure–response functions for each level of physical intensity (derived in step 5).	Potential daylight working hours in each small geographical area and corresponding working hours lost per worker.
7. Calculation of total working hours lost by countries and sub-regions	(a) Daylight hours lost per worker in each small geographical area; (b) Number of workers in each sector for each small geographical area.	Percentage of potential working hours lost for each level of physical work intensity (200 W / 300 W / 400 W).
8. Calculation of Tanzania's ASGM workforce in 2030	(a) ASGM employment estimates (AGENDA, 2015) (b) Tanzania: Population projections from 2015 – 2030 (Tanzania, 2018).	Tanzania's ASGM workforce in 2030
9. Calculation of total hours lost by Tanzanian ASGM workers in 2030	(a) ASGM workforce estimates in 2030 from step 8 (b) Percentage of lost working hours from sector whose worker profile best matches that of ASGM workers (agriculture/400W) as calculated in step 7 (c) Average wage estimates in ASGM (Merket, 2019)	- Total hours lost by Tanzanian ASGM workers due to heat stress in 2030 - Total lost wages by Tanzanian ASGM workers due to heat stress in 2030

While this methodology can provide an estimate of the future impacts of climate change in Tanzania's ASGM sector, it has limitations that affect its precision. The model uses the best available data on employment in the sector. However, it is widely acknowledged that the remote and often informal nature of ASM makes its employment figures inconclusive. The model is based on climate models; therefore, it is informed by the assumptions in those climate models.

The methodology does not take into account potential job losses due to an increase or decrease in rainfall or a rapid growth rate of ASM employment due to the impact of climate change-induced job loss in sectors such as agriculture. The model also makes use of averages in estimates on wages and the use of averages has documented shortcomings (Savage, 2009). The model also assumes that all ASGM workers in Tanzania work in conditions with a physical work intensity of 400 W. Lastly, the model is simply a model, a representation of reality used to shed some light on potential outcomes; it uses the best available data as inputs and is based on acceptable ILO methodology.

Labour trends in Tanzania and ASGM

Tanzania's unemployment rate has steadily improved over the last decade, decreasing from a high of 3.47 percent in 2012 to 1.99 percent in 2019 (Statista, 2019a). Between 2009 and 2019, the country's employment-by-sector statistics remained largely unchanged. Agriculture continues to be the primary employment sector, providing 65 percent of employment in 2019, compared to 70.92 percent in 2009 (Statista, 2019b). This relatively small change is still a positive, as it shows signs of greater diversification in the economy.

Tanzania's poverty reduction efforts have led to a decrease in the percentage of Tanzanians living in poverty, from 34 percent in 2007 to 26.4 percent in 2019 (World Bank, 2019b). Unfortunately, over a similar period, the number of people living in poverty has increased by one million. Approximately half of Tanzanians continue to live below the international poverty line of USD 1.90 per person per day. The poverty and unemployment rates are important as the literature shows that "to a large extent, informal mining is a poverty-driven activity" (Barry, 1996). This is true in Tanzania and similar observations have been made in other countries on the continent, including Ghana (Wilson et al., 2015).

ASM in Tanzania was estimated to employ 550,000 individuals; the Economic Commission of Africa estimates that approximately 1.5 million were associated with the sector in 2020 (UNECA, 2020). Some researchers have traced the growth of the sector back to as far as Tanzania's structural adjustment policies (SAPs) in the 1980s. These policies created two significant impacts that expanded the ASM sector, namely the privatisation of many social services, which led to major layoffs of public-sector workers, and the reconfiguration of rural markets, which led to an exodus from smallholder farming (Kwai & Hilson, 2010). Given this context, the paper proceeds to explore the future projections of employment in Tanzania's ASGM sector, in view of the warming impacts of climate change.

Results

The ILO estimates that, in 2030, Tanzania's agriculture, industry, construction and services sectors combined will lose 303,000 full-time jobs due to lost hours as a result of heat stress. By sector, agriculture will lose 1.12 percent of its job hours, industry will lose 0.36 percent, construction will lose 1.12 percent and services will lose 0.02 cent. The impact of heat stress on each sector is dependent on the physical nature of the work that the majority of the sector's participants undertake. For instance, there is much less impact on the services sector compared to the other sectors that involve more physically intense activities. These estimates are based on the assumption that all work in these sectors will happen in the shade.

For the purposes of this study, the percentage of lost working hours from Tanzania's agricultural sector due to heat stress is used as a proxy to estimate the impact of warming on the country's ASGM sector. This works from the assumption that the 400 W metabolic rate that is used to estimate the productivity losses and health risks in agriculture as heat levels rise is similar in artisanal miners. The result of this modelling exercise is summarised in Table 8.4. The table provides two scenarios, with and without shade, which show a significant decrease in jobs for the ASGM sector as a result of heat stress.

Table 8.4. Impact of heat stress on Tanzania's ASGM workers – 2030. (***Source:*** *Results of the analysis in Table 8.3.)*

	Total job losses in ASGM (1.12%)	Lost Wages (in USD)
Scenario 1 (with shade)	11,062	10,885,126 - 14,601,998
Scenario 2 (without shade)	22,124	21,770,016 - 29,203,996

As noted earlier, the majority of individuals who work in ASM do so as a result of push factors, such as the need to supplement their agriculture-related income or to create a new livelihood or because of a lack of economic activities. The impact of heat stress means that upwards of 11,000 of Tanzania's ASGM workforce will be unable to depend on ASGM as a route to alleviate their poverty.

While at a macro-level, the lost wages estimated above are not significant, at a micro-level the impacts are expected to be considerable, given the dependency of families on ASGM and the link between the sector and economic activities in communities. From the statistics provided above on employment and dependants, it is established that there are thousands of individuals and families who depend on the revenue earned in the form of wages by ASGM miners.

The studies conducted on ASM also show that the sector's activities have well-established links with other activities in local economies. In some locations, small businesses in communities are created from the demand for products and services by ASM operators. ASM operations contribute to the creation of non-mining jobs by supporting and even investing in small businesses, such as shops, taxis, bars, guesthouses and farming (African Union, 2009).

The other consequence that can be linked to these job losses is a decrease in production. While this exercise did not calculate the significant impact that the productivity loss will have on gold output, one could expect a cascading effect such that, in turn, it will negatively impact the sector, ASGM mining communities and the entire value chain that is built on the physical labour of Tanzania's ASGM workforce.

The productivity impacts are further worsened when using ILO estimates of the impact of heat stress, if one assumes all the work is done outside and without shade.

This necessitates adding an additional 2°C to the in-shade WBGT. The ILO does not provide precise estimates for job losses due to heat stress in Tanzania when working directly in the sun. It does however show that, as a region, East Africa would endure more than double the lost hours due to heat stress if activities are performed without shade. This could mean losing approximately 22,584 jobs and result in income loss of upwards of USD 29 million in wages.

Implications for policymaking

Minerals are one of the natural resources that the Tanzanian economy is dependent on, and a significant percentage of the total national production, including gold, is produced by ASM. While the Tanzanian policy and legal framework for ASM provides for environmental management, no specific reference is made to climate change. It is reported that an environmental protection plan (EPP) that is required when obtaining a PML is meant to cover issues of climate change. However, this has not been tested through a review of an actual EPP. At the time that the Tanzania National Adaptation Programme of Action (NAPA) was produced in 2007 by the Division of Environment in the Tanzanian Vice President's Office, mining was not one of the priority areas though it was included in the National Climate Change Strategy (NCCS) of 2012.

The high-level ASM sector analysis done, as part of this research, identifies the need for explicit provisions for climate change issues for the ASM sector. This report therefore puts forward suggestions as to how this could be covered. As 'living documents', it is assumed that Tanzania's NAPA and NCCS provide space to accommodate the increased importance of the mining sector to the country's economy.

The previous sections of this report constitute high-level sectoral analysis and have undertaken a high-level vulnerability assessment on the impacts of climate change on the ASGM sector (high-level assessment because it was done with no baseline on the ground data due to constraints on resources). It is against these vulnerabilities that the analysis presented here puts forward ideas on some of the adaptation strategies that could be taken for the ASM sector in Tanzania. The strategies are meant to build resilience to the impacts of climate change by improving the following:Adaptive capacity through improved preparedness for climate change-induced events

- Absorptive capacity when climate-related events are occurring to limit harm to the lives of people

- Transformative capacity, so that people are able to move forward after the climate events

All the objectives of the Tanzania NAPA and the NCCS intersect with issues of the ASM sector. Further work would need to be done to satisfy the guiding principles detailed in the NAPA, which include:

1. *A participatory approach*: For the ASM sector, the participatory approach should endeavour to include miners and their representative associations, such as FEMATA and TAWOMA, the mining hosting communities, and those entities responsible for policy, regulation and administration of the sector (such the Ministry of Mines, the Mining Commission, NEMC and the Land Commission), local government (i.e., regional, district and village authorities).
2. *Multidisciplinary approach*: ASM touches on many disciplines, which should be included; for example, mining, geology, environment, social, health, safety, security and trade.
3. *Complementary approach*: Existing initiatives should be considered. Examples include the national development strategies, like the National Vision 2025, Mkukuta (the National Strategy for Growth and Reduction of Poverty), and interventions for the Minamata Convention, domestication of the AMV and ICGLR frameworks).
4. *Sustainable development*: All Tanzania's initiatives with respect to sustainable development, particularly those aligned to the SDGs, should be considered for alignment.
5. *Country-driven*: Since the NAPA is a country-driven exercise, the government should take a leadership role in incorporating the ASM aspects. The national frameworks that are important in the process are the Mining Act of 2010, the Environmental Management Act and the Land Act.
6. *Flexibility*: The uncertain nature of climate change impacts make it imperative that the process be flexible and agility be built into all strategies and related projects. This will mean allowing space for other actors like the LSMs, NGOs and research institutions.

Building on the objectives of the NCCS, the following considerations for the ASM sector are put forward:

1. *Capacity building*: This should include building the capacity of public institutions to lead the strategic approach for the ASM sector; for example, the Mining Commission, the National Environment Management Council (NEMC) and local government. The capacity of miners and their representative organisations should also be built up to understand and implement adaptation and mitigation activities in their mining operations.
2. *Enhanced resilience*: Specific activities will need to be identified to enable the ASM sector to build resilience through adaptive, absorptive and transformative interventions.
3. *Accessibility and utilisation of climate change opportunities*: There are opportunities that exist that the ASM sector could take advantage of to be resilient to the impacts of climate change. One of these is the movement towards the formalisation of the sector, which the Tanzanian Government is already supporting.
4. *Mitigation activities and sustainable development*: Mitigation activities are aligned to the SDGs. It is important to also consider the potential for collaboration with interventions that are targeting the attainment of the SDGs.
5. *Public awareness*: Public awareness of the role the ASM sector plays in the climate change agenda.
6. *Information management*: Management of the ASM sector's information is already part of the regulatory framework in Tanzania. It needs to be adapted so that the baseline and ongoing monitoring data for climate change parameters are captured.
7. *Institutional arrangements*: These arrangements should ensure strategic leadership and oversight, support and guidance to the ASM sector and their representative organisations to understand and implement adaptation and mitigation activities in their mining operations.
8. *Mobilisation of resources*: Resource mobilisation can be done through existing interventions and programmes already targeting the ASM sector. For example, the National Action Plans for ASGM under UNEP's framework

for the Minamata Convention on Mercury Pollution have formalisation at their core; the formalisation activities could be aligned to climate change adaptation and mitigation measures.

The following section makes high-level recommendations on adaptation and mitigation strategies in line with the Tanzania NAPA and NCCS.

Table 8.5. Potential ASM adaptation strategies for climate change-induced temperature increases in Tanzania. *(**Source:** Created by Nellie Mutemeri, Itai Mutemeri and Pontsho F. Ledwaba-Twala.)*

Indirect or Secondary Stressor	Potential Climate Change Impacts	Adaptation/Mitigation Strategies
• Increased temperatures will limit the amount of physically intensive work that can be performed • Increased temperatures are expected to reduce the length of the growing season for some crops and encourage disease and pest eruption	Impacts on-site	
	• Fewer daytime working hours leading to lost jobs on-site	• Introduce some mechanisation to improve productivity during the limited working hours • Adapt working schedules and introduce means of working during the coolest hours of the day/ night • Introduce alternative livelihoods and social nets for those who lose their jobs

Indirect or Secondary Stressor	Potential Climate Change Impacts	Adaptation/Mitigation Strategies
• Increased temperatures may result in decreased soil moisture which would affect runoff and river flows • Increased risk of wildfires	• Lower productivity of workers because of heat stress and related lower energy levels	• Redesign mines to improve ventilation and cooling • Adapt working schedules to work during the coolest hours of the day/night
	• Inability to access some underground workings where the ventilation and cooling is poor	• Use different mining methods where possible, for example, open pit • Redesign mines to improve ventilation and cooling
	• Poor underground support because of difficulties in accessing underground timber support; timber lost in forest fires	• Use different types of support • Redesign mining methods
	• Pressure to access new shallower deposits posing a risk to protected areas, such as forest and game reserves	• Educate ASM communities on the value of the protected areas • Identify alternative livelihoods for ASM miners near protected areas • Improved enforcement from regulatory authorities • Co-opting miners through their organisations into participatory self-regulation

Indirect or Secondary Stressor	Potential Climate Change Impacts	Adaptation/Mitigation Strategies
	• Changes in shifts with working hours pushed to night-time and this may lead to accidents because of a lack of resources to operate at night (i.e., adequate lighting)	• Assist the miners with the installation of lighting infrastructure. • Provide appropriate PPE for working during night shifts • Put in place security measures to ensure that the miners are safe during their shift
	• Employee health may be compromised because of heat-related diseases and vector-borne diseases	• Redesign shifts and working hours to avoid fatigue • Put in place cooling systems and improve ventilation in underground mines
	• Impacts off-site	
	• Loss of livelihoods for people dependent on mining and smallholder farming	• Implement alternative livelihoods • Introduce other social safety nets
	• Loss of jobs from LSM because of higher operating costs (pushing people into informal ASGM)	• Introduce alternative livelihoods • Introduce other social safety nets • Transform some of the LSM assets into ASM operations which have lower capital requirements and lower job creation costs

Table 8.6. Potential ASM adaptation strategies for climate change-induced rainfall increases in Tanzania. (***Source:*** Created by Nellie Mutemeri, Itai Mutemeri and Pontsho F. Ledwaba-Twala.)

Indirect or Secondary Stressor	Potential Climate Change Impacts	Adaptation/Mitigation Strategies
Increased rainfall could increase risks of flooding in some areas.	• Impacts on-site	
	• Flooding of open pits and underground shafts, therefore limiting access	• Improved mine design to manage water ingress underground • Improved dewatering methods, and supporting access to appropriate capacity pumps for ASM operations
	• Damage to tailings storage facilities and settling ponds	• Improved design of tailings storage facilities • Monitoring of the integrity of tailings storage facilities • Training of ASM operators on managing TSF and settling ponds
	• Damage to mine infrastructure leading to a loss of operations	• Improved design of storm drainage infrastructure
	• Increase in water-borne diseases decreasing productivity of workers	• Backfilling of mining pits to reduce stagnant water • Preventive measures for water-borne disease, like provision of clean water and improved water, sanitation and hygiene (WASH) facilities

Indirect or Secondary Stressor	Potential Climate Change Impacts	Adaptation/Mitigation Strategies
	• Increase in operating costs, for example, dewatering equipment will be required to drain water out of working areas	• The provision of central and shared equipment which operators can loan out for use in operations
	• Impacts off-site	
	• Damage to public infrastructure like roads, bridges, power lines, leading to lost operating hours and less viable ASGM operations. This may also lead to displacement of communities and loss of livelihoods.	• Improved management of inputs stock inventory • Alternative livelihoods for miners who lose their jobs • Training and capacity building on emergencies and natural disaster responses
	• Increase in the number of informal/ illegal miners due to push factors (a loss of agricultural livelihoods because of flooding)	• Strengthened enforcement capacity • Enhanced capacity for formalisation where the mineral resources exists • Alternative livelihoods for those who have lost livelihoods • Institute social safety net interventions

***Table 8.7**.* Potential ASM adaptation strategies for climate change-induced rainfall decreases in Tanzania. *(**Source:** Created by Nellie Mutemeri, Itai Mutemeri and Pontsho F. Ledwaba-Twala.)*

Indirect or Secondary Stressor	Potential Climate Change Impacts	Adaptation Strategies
Changes in availability of water sources	• Reduced business viability because of a scarcity of water for running mining operations, particularly processing	• Implementation of water recycling methods • Implementation of more water-efficient processes
	• Poor water sanitation and hygiene conditions because of limited access to water	• Implementation of alternative hygiene and sanitation methods that are more water-efficient
	• Employees' health may be affected because of a lack of clean water	• Provision of clean water at mining sites • Education and awareness on water-borne diseases
	• Impacts off-site	
	• Increase in numbers of informal/illegal miners due to a loss of agricultural livelihoods because of drought. In-migration can be expected to include foreigners from neighbouring countries due to porous national borders. This could result in pressure on social services.	• Alternative livelihoods for people who have lost their traditional livelihoods • Better management of refugee issues, for example, provision of livelihoods and social services

Indirect or Secondary Stressor	Potential Climate Change Impacts	Adaptation Strategies
	• Increase in competition for water resources resulting in conflicts between ASGM and community members (i.e., farmers).	• Development of available water resource apportioning systems, including putting in place systems to monitor water wastage • Promote the recycling of water in operations • Set up water-treatment plants to clean polluted water
	• Drought conditions can exacerbate food insecurity because of poor crop production	• Alternative livelihoods for people that have lost their traditional livelihoods • Identification of arable land for crop production
	• The health of communities may be compromised because of vector-borne diseases and illnesses from poor hygienic conditions	• Provision of basic services, i.e., water and sanitation • Education and awareness of vector-borne diseases and illnesses from poor hygienic conditions

Conclusion

The main conclusion of this paper is that, given the increasing importance of ASM to the economy of Tanzania, it is important that it is well incorporated into the climate change strategy of the country. It is recommended that an adaptation planning exercise similar to the one carried out for other sectors be carried out for LSM and ASM. This will ensure that the climate adaptation and mitigation strategies put forward for the ASM sector are informed by a thorough sector analysis. In addition, the process should be aligned to the guiding principles expounded in the NAPA.

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9
Understanding the Linkages Between Climate Change and Gold Mining in Sub-Saharan Africa: A Systematic Review of Ghana

Samuel Obiri, Reginald Quansah and Samuel Jerry Cobbina

Abstract

This paper systematically discusses the relationship between climate change and gold mining in sub-Saharan Africa using Ghana as a case study. The paper highlights the effects of climate change on mine infrastructure as well as socio-economic, human health and the likely environmental impact on host communities. Adopting a framework developed by Odell et al. (2018), the paper's main thrust is fourfold. First, it establishes a claim that there is a significant relationship between mining and climate change. Secondly, it discusses and analyses the current scientific literature on the subject of gold mining in sub-Saharan Africa. Thirdly, it sets an agenda for future research on the subject. Finally, it discusses the impact of the conversion of large portions of the tropical evergreen rain forest in Ghana into mining activities by small or large-scale companies and its resultant effect on rainfall pattern. The paper concludes that, even though mining firms as well as host communities in mineral-rich countries in sub-Saharan Africa, such as Ghana, have been experiencing the negative effects of climate change, there is limited literature on this subject in the country and in many gold-producing countries in sub-Saharan Africa.

Introduction

Gold mining in Ghana has been a major pillar on which the nation's development has relied since independence. The gold mining industries have contributed immensely to the country's economic growth with figures from the Ghana Extractive Industries Transparency Initiative (GHEITI) suggesting that the sector's contribution to GDP increased from 9.5 percent in 2012 to 9.8 percent in 2014, accounting for total foreign exchange earnings of USD 3,192648 (GHEITI, 2014). Currently, about 20 percent of the country's total land surface of Ghana is under mineral concessions held by either large-scale mining companies or licensed small-scale mining companies (Schueler et al., 2011; Kumi-Boateng & Stemn, 2020).

Gold mining in Ghana began long before the advent of colonialism, when the metal was mined using indigenous techniques (Hilson, 2006). The use of modern technology was adopted as far back as AD 1880 in Tarkwa and was extended to Obuasi in 1898 (Hilson, 2002). Now there are growing concerns over negative impacts associated with mining operations in the country as a whole and mining host communities in particular. For instance, Al-Hassan (2007) noted that rainfall patterns in most mining communities in the Tarkwa mining area, an important mining hub in Ghana located within the moist deciduous evergreen tropical rainforest, have recently become erratic. According to Al-Hassan (2007), this erratic pattern can be attributed to the increasing number of surface gold mining companies operating in the area. Other key concerns that have been noted are as follows:

- Does pollution of water bodies through the improper discharge of mine waste cause any concern?
- Does climate change pose a threat to mining industry infrastructure?
- Are there opportunities associated with climate change that the mining industry can take advantage of?
- What adaptation measures should be undertaken by mining companies and host communities to address the impact of climate change?
- Do residents of mining communities have the opportunity to choose between better living standards and reasonable environmental quality, such as the right to clean water?

Another key environmental concern that has been noted globally, and which is expected to impact negatively on economies of most countries in sub-Saharan Africa, is the issue of the relationship between climate change and mining. For example, questions being asked about this relationship include: what are the opportunities that climate change offers for mining industries in Ghana? How should mining companies adapt their operations to suit climate change? And how should host mining communities respond to the threat of climate change? These questions are particularly important because the gold mining industry is a major economic player in Ghana. It is also seen as a major contributor to climate change due to the sector's emission of greenhouse gases (GHG) produced in extremely energy-intensive processes. In this context, the gold mining industry has a significant role to play in the discourse of climate-change reduction and adaptation, given the nexus between the two on the earth's biosphere, ways of life, and the development of the Ghanaian economy.

Climate change will impact the extractives industry sector in several ways, generating both threats and opportunities; however, this nexus is hardly articulated in the context of the implications for sustainable development and climate-change mitigation. It is interesting to note that the attention of most of the scientific literature that exists on mining in sub-Saharan Africa, and hence Ghana, is centred on assessing the impact of mining on the environment, socio-economic livelihoods and human health of residents in host communities, corporate social responsibility, compensation and human right violations among others. Scientific studies on climate change have so far basically focused on the impact of climate change on food security (Armah et al., 2014). Therefore, given the fact that there is a lack of scientific literature on the link between gold mining and climate change in sub-Saharan Africa, this paper seeks to do a systematic review of these issues against the backdrop that the gold mining industry has a significant role to play in the discourse of climate-change reduction and adaptation; this is especially because of the nexus between the two on the earth's biosphere, way of life, and the development of the Ghanaian economy. Climate change will impact the extractive industry in several ways, generating both threats and opportunities; however, this nexus is hardly articulated in the context of the implications for sustainable development and climate-change mitigation.

The concerns have culminated in the call for a study to understand the nexus between climate change and the gold-mining industry in Ghana. As the world begins to transition to cleaner energy generation and use, core fossil fuel commodities as well as other metals may come under pressure and the demand for these metals may increase as investments in infrastructure are made for a 'net zero carbon' future (WIDER-UNU, 2017).

Objectives

- The overall objective of this paper is to conduct a systematic review of the nexus between climate change and gold mining in sub-Saharan Africa using Ghana as a case study. The specific objectives are as follows:
- To find out whether there is evidence of a link between gold mining and climate change in the major gold deposits in Ghana, such as the tropical evergreen rain forest agro-ecological zone, where there is an intensive mining operation which has resulted in deforestation, a major driver of climate change;
- To assess the carbon-dioxide footprint of mining, regarding the emission of GHG of the gold-mining industry with particular reference to large-scale mining companies;
- To adopt and use a framework developed by Odell et al. (2018) to discuss and analyse the current scientific literature on this subject in sub-Saharan Africa using Ghana as a case study; and,
- To set an agenda for future research on the relationship between mining and climate-change in sub-Saharan African countries such as Ghana.

Ghana's national climate-change policy

Climate change is regarded as one of the biggest challenges facing most countries in the world in the 21st century. As a global challenge, it requires global solutions. The threat of climate change is multidimensional and its impact transcends national borders. Scientific projections from the Intergovernmental Panel on Climate Change (IPCC) indicate that, if emissions of GHG continue to rise at their current pace, the world will be faced with a disastrous future in the form of sea-level rise, shifts in growing seasons and biodiversity loss as well as increased frequency and intensity of extreme weather events such as heatwaves, storms, floods and droughts.

In recent times, Ghana has been experiencing some of the negative effects associated with climate change, the consequences of which have been predicted to have a serious impact on the country's economy, health, agriculture, fisheries, water resources and energy (Ghana, 2013). Pursuant to Article 36, clause 9 of the 1992 *Constitution of Ghana*, the government is enjoined to seek collaboration with international organisations for the purposes of protecting the environment. It was in line with this constitutional provision that Ghana signed the Kyoto Protocol as well as the Paris Agreement, all aimed at reducing emissions of GHGs with the sole aim of addressing global climate change.

Ghana's national climate-change policy developed in response to the threat and opportunities associated with global climate-change priority areas are the agriculture, water resources, fisheries and energy sectors of the economy. Thus, this omitted an important sector of the Ghanaian economy; that is, the gold-mining sector. However, even though Ghana's National Minerals and Mining Policy, launched in 2015, acknowledges that climate change will have a significant impact on the mining industry, the supposed impacts have not been adequately addressed in both the National Climate Change Policy as well as the Minerals and Mining Policy. Emissions of GHGs from the gold-mining industries are also not effectively addressed in Ghana's greenhouse inventory report, as well as other important documents.

Conceptual framework

The conceptual framework for this paper was adopted from Odell et al. (2018). The simple framework summarises the relationship between mining and climate change as well as the interactions of these concepts with the larger society (Figure 9.1). From the figure, five themes emerged that describe the relationship and interactions. In this paper, the existing literature on this subject is organised into each of the six themes identified in the framework.

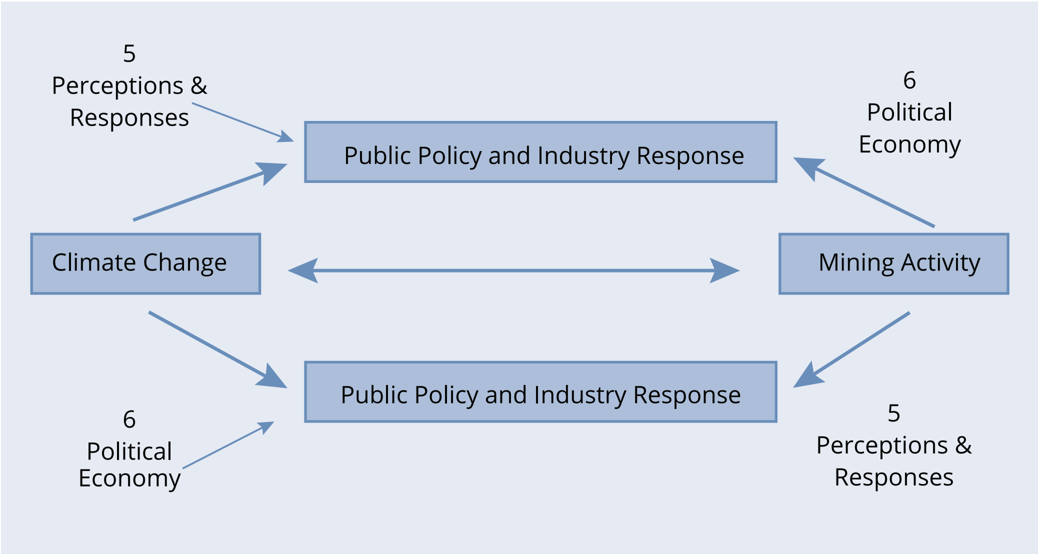


Fig 9.1. Conceptual framework showing the interactions between the six thematic areas. *(**Source**: Adapted from Odell et al., (2018)).*

Theme 1 refers to either peer-reviewed papers or reports that discuss the way in which climate change directly affects mining operations. Theme 2 discusses peer-reviewed literature or reports on how mining activities are directly contributing to climate change. Theme 3 looks at the literature that discusses responses to relationships between mining and climate change from the government's and the public's point of view, as well as that of the mining industry players. Theme 4 looks at articles that discuss other environmental and social impacts that intersect with the interactions between the mining and climate-change relationship. Theme looks at the literature discussing perceptions and responses from civil society organisations, residents of mining communities, industry and government actors that in turn affect public policy and industry practice (Theme 3), thus creating either a positive or negative feedback loop.

Methodology

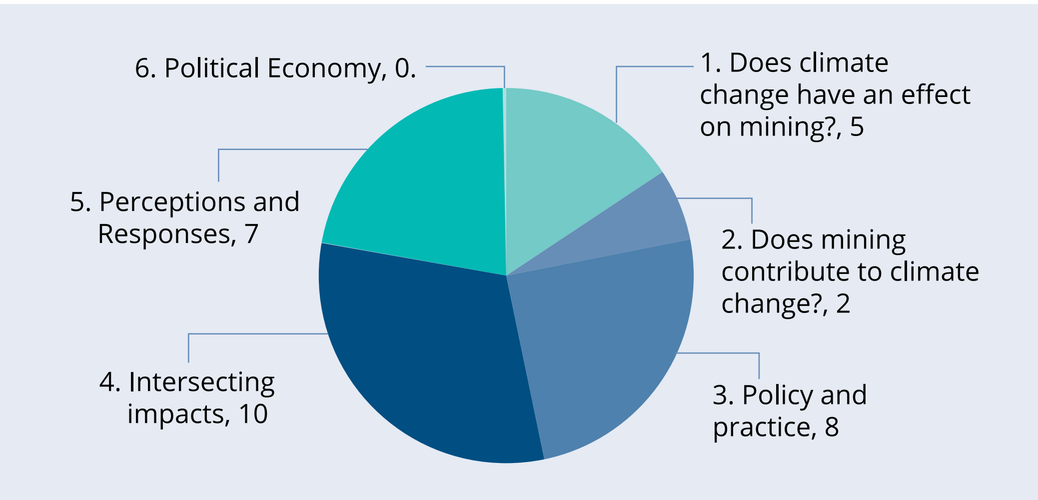
Based on the adopted conceptual framework from Odell et al. (2018), the desktop search was limited to peer-reviewed articles as well as reports that discussed mining and climate change as a central theme; they did not include those mentioning climate change in passing when discussing the environmental impact of mining. This was done to assess the scope of understanding of the mining and climate-change discourse in the literature or other technical reports on this subject in Ghana as well as other sub-Saharan African countries. In this regard, the search was conducted from the various search engines using a combination of words such as “mining” or “mine” or “mines” or “miner” or “minerals” or “mineral” interchangeably with “climate change” or “global warming”. The articles were sourced from web of science, Scopus, PubMed and other search-engine databases.

Results and discussion

Data extraction

From the desktop search, over 140 peer-reviewed papers as well as reports from the various search engines were extracted. Out these, 32 articles were found to be relevant to the subject under discussion. These articles, or reports, were grouped into the six themes identified in the framework and are summarised in Figure 9.2.

Fig 9.2. Categorisation of extracted articles and reports into the six thematic issues
*(**Source:** Odell, S. D., Bebbington, A. and Frey, K. E. (2018):*



From Figure 9.2, the distribution of the articles shows that the adopted framework was appropriate and suitable in synthesising the mining and climate-change relationship. For example, five articles discussed whether climate change has any effect on mining operations in mineral-rich countries. Articles within this category discussed such issues as whether climate change has affected a mine from operating or whether, as a result of climate change, new minerals or mining have taken place in areas that were hitherto not accessible. Similar observations were made for the other themes except the sixth theme (i.e., political economic considerations) within which the mining and climate-change discussion are taking place. It emerged that the sixth theme has not received much attention from scholars working on this subject.

Theme 1: Does climate change affect gold-mining operations in Ghana?

It is interesting to note that there was no article or report from Ghana, or any of the sub-Saharan Africa mineral-rich countries, out of the five articles or scientific reports extracted that explicitly discussed this topic. The articles and reports on this theme cited studies conducted in either Australia or Canada. The central theme that ran across these papers and reports were as follows:

1. *Gold-mining operations are vulnerable to the ravaging effects of climate change* (Ford et al., 2011; Ford et al., 2010; Arent et. al., 2014; Pearce et. al., 2011; Danigos, 2012). These authors argue that climate change is likely to increase the operating, transportation and decommissioning costs of mining companies attributed to increasing extreme weather events such as bushfires, flooding and wind storms. According to them, most mining infrastructure and planning processes were done based on the fact that the climate would remain stable during the mine life cycle.

2. *Climate change could open new mineral-rich resource areas which were hitherto not accessible for mining,* for instance, Mager (2000) argues that climate change would make it possible for mining operations to be extended and to take centre stage in countries in the Arctic regions. This will be made possible due to the rising temperatures that will cause most of the ice that had covered these mineral resources to melt, thus paving the way for their extraction.

3. Climate change would help to shift the attention of mining industry players from the traditional minerals to new ones considered clean as the world moves towards a cleaner or green economy Hund, et al., 2020)

Just as both mining companies and government regulatory agencies in mineral-rich countries in Asia and Latin America are conscious of the impact of climate change on gold-mining operations, in the case of Ghana, the environmental impact assessment (EIA) statements do not discuss whether climate change would significantly impact the companies' mining operations. This is despite factoring in the impact of climate change on their operations into their EIAs Majority of the mining companies' EIAs do not even contain baseline data on climatic variables, such as temperature or rainfall values. Even when the EIAs include baseline climatic data, these data are not analysed so as to enable the prediction of the likely impact of climate change on the companies' mining operations.

Theme 2: Does gold mining in Ghana contribute to climate change?

According to Kesse (1985), geologically, the moist deciduous evergreen tropical rainforest is underlain by the Birimian and Tarkwaian rock system, which are rich in minerals such as gold, bauxite and manganese. Besides the presence of rich minerals, the soil is very fertile and supports the growth of food crops as well as cash crops like cocoa and coffee (Akabzaa, 2000, pp. 32-33). The high rainfall values coupled with its high humidity and high temperature nourish the plants (Baffoe, 2004, pp. 9-14).

Due to the richness in minerals within the moist deciduous evergreen tropical rain forest, mining activity dates as far back as 1880 when a modern gold mine was established in Tarkwa. The activities were later extended to places like Prestea and Obuasi (Obiri et al., 2006; Akabzaa, 2000). The area is described as the mining hub in sub-Saharan Africa as it plays host to many large-scale mining companies, registered artisanal and small-scale mining companies as well as those inhabitants engaged in illegal popularly called '*galamsey*' (meaning 'gather and sell').

The low gold prices and high operating cost between the 1970s and early 1980s resulted in the closure of most of the gold mines operating in Ghana and especially the moist deciduous evergreen rainforest. However, as part of the Economic Recovery Programme (ERP) implemented by the Provisional National Defence Council (PNDC) government in the mid-1980s, the mining sector was liberalised. Coupled with increasing gold prices on the world market, the number of both large-scale and artisanal small-scale mining companies as well as illegal operators increased. Figures 9.3 and 9.4 show the satellite image of Prestea, Huni Valley District, in 1986 and 2020 respectively. The former shows there was more green vegetation compared to the vegetation index for the same area in the latter.

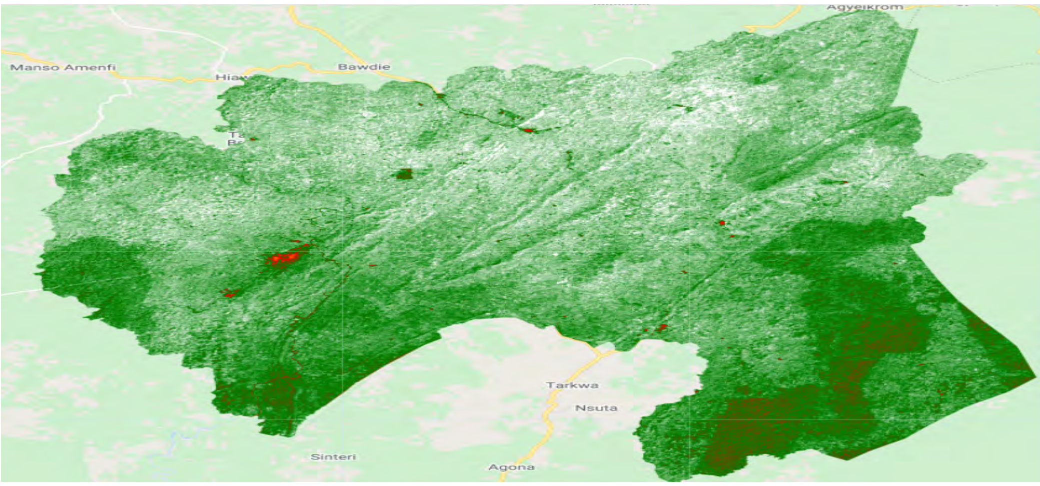


Fig 9.3. A satellite image of Prestea Huni Valley District in 1986.

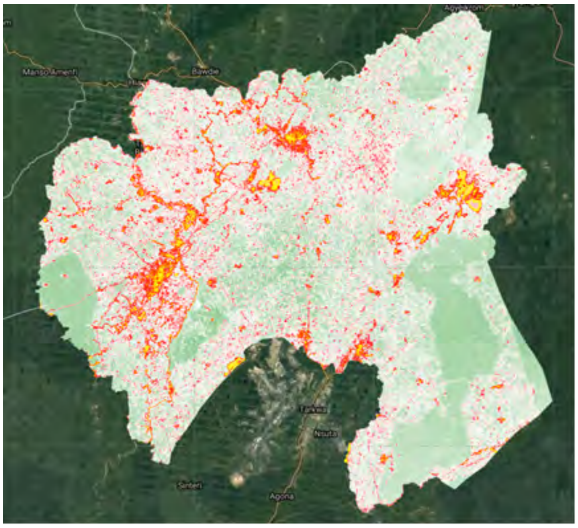


Fig 9.4. A satellite image of Prestea Huni Valley District in 2020. *(Source: CERGIS, 2020.)*

Note: The red patches in both figures show large-scale mining companies, while the yellow patches indicate artisanal small-scale mining companies. The white patches represent farms.

From the two figures, it can be seen that there was increased mining operations in the Prestea, Huni Valley District, from 1986 to 2020. The activities have resulted in a massive reduction in forest cover, which controls the climate of the area. A study by Schueler et al. (2011) also provides a detailed explanation of the figures (9.3 and 9.4). The authors argued that the increased gold-mining activities in the moist deciduous evergreen tropical rainforest, which comprises Tarkwa, Nsuaem Municipality, and

Prestea, Huni Valley District, have resulted in widespread land cover changes between 1986 and 2002. For example, according to the authors, in 1986, only a small area was used for surface mining (0.2% of the mining concession area, representing 33 ha, Table 9.1), but, in 2002, mining areas had expanded to 41.9 percent of the concession areas.

Table 9.1*.* Land cover changes between 1986 and 2002 in the Damang, Bogoso-Prestea and Tarkwa mining concessions in the moist deciduous evergreen tropical rainforest climatic zone.

	Degraded Forest	Farmland Loss	Permanent Forest	Permanent Mine	Permanent Farmland	Farmland Extension	Sum per Concession
Damang	51.2 ha (2.55%)	1099.0 ha (54.66%)	166.6 ha (8.29%)	5.7 ha 0.28%)	649.6 ha 32.31%)	38.3 ha (1.90%)	2010.5 ha (100%)
BogosoPrestea	449.2 ha (7.56%)	1739.8 ha (29.30%)	282.8 ha (4.76%)	1.8 ha (0.03%)	2735.3 ha (46.06%)	729.8 ha (12.29%)	5938.7 ha (100%)
Tarkwa	2667.1 ha (16.36%)	2096.6 ha (18.38%)	1775.3 ha (15.56%)	25.5 ha (0.22%)	2545.2 ha (22.31%)	2298.7 ha (20.15%)	11408.8 ha (100%)
Total (Σ)	3167.6 ha	4935.3 ha	2224.8 ha	33.0 ha	5930.2 ha	3066.7 ha	19357.5 ha
MCP*	16.36%	25.50%	11.49%	0.17%	30.63%	15.84%	100%

**MCP: Mean class proportion across all three concessions (Source: Schueler et al. (2011)).*

From Table 9.1, it can be seen that about 3,168 ha of forests was cleared within the Tarkwa Rain Forest agro-ecological area for gold-mining pits between 1986 and 2002. This represents 16.4 percent of the total mining concessions given to large-scale mining companies operating within that ecological zone. The clearing was at the expense of the forest reserve, which was supposed to have acted as a carbon sink to GHGs from the mining operations while at the same time controlling climatic variables such as rainfall and temperature.

Moreover, a total of 4,935 ha, representing 25.5 percent of farmlands owned by residents in the agro-ecological zone, were taken over for large-scale gold-mining operations. The overall effect of this action, coupled with the fact that the destruction of the forest cover is likely to cause erratic climatic conditions such as declining rainfall and temperature, may negatively affect agricultural production, hence destroying the livelihood of most residents. Thus, the reduction in the forest cover of the area has contributed to variation in rainfall values as shown in Figure 9.5.

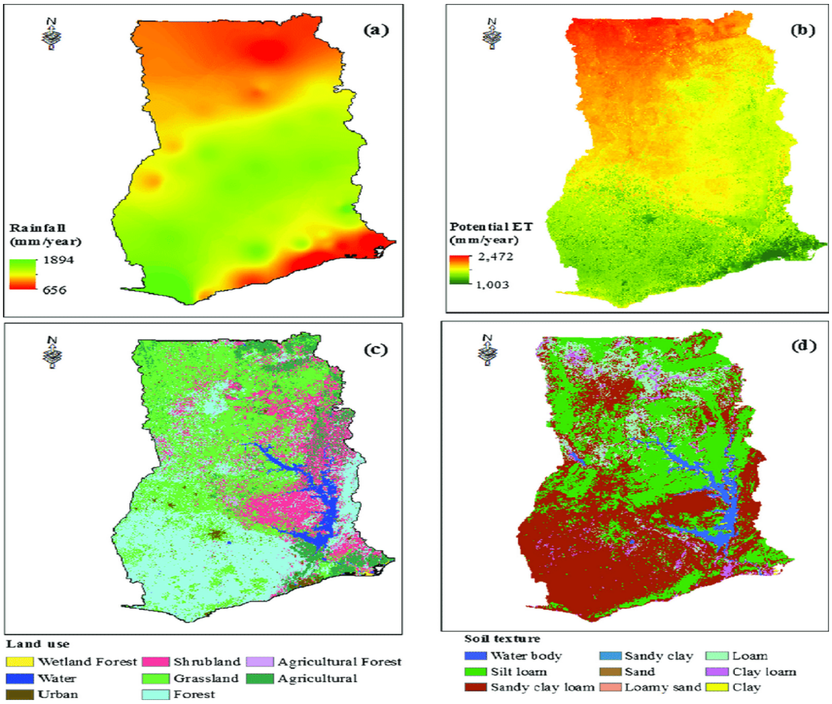


Fig 9.5. Variations in rainfall values in Ghana. *(**Source:** Map reproduced from Worqlul et al. (2019)).*

From the foregoing discussion, it can be noted that there is a causal relationship between mining and climate change within the moist deciduous evergreen rainforest in Ghana. This suggests the need for deeper studies to understand this type of relationship. Furthermore, recent studies by Worqlul et al. (2019), as well as Schueler et al. (2011), confirmed an earlier causal relationship between the impact of large-scale gold mining and the rainfall pattern in Tarkwa, Nsuaem Municipality, a district within the area, by Al-Hassan (2007) who established that increases in the number of surface-mining companies has resulted in massive destruction of the forest cover and a decline in rainfall values.

The link between climate change and mining in Ghana has not been thoroughly investigated by scientists. The closest of the studies that attempted to address this gap is by Amoako et al. (2012). The study assessed the carbon footprint of 12 large-scale gold-mining companies operating with the authors arguing that the total GHG emission from the operations of a typical large-scale mining company operating an open-pit mine (i.e., surface mining) averaged a total of 1.497 KgCO_2/t per year against the global average of 69.5 KgCO2/t by Norgate and Haque (2012). The authors had set six key criteria that included land use, blasting, mobile combustion (including emissions from the vehicles used by companies), stationary combustion, electricity used and waste emitted. Thus, the mean total CO_2 emission from the mining of gold ore in Ghana is lower than values recorded in the literature from other countries. The picture may change completely if licensed artisanal small-scale gold-mining operations as well as the illegal artisanal small-scale gold-mining entities are taken into consideration.

The observation made by Amoako et al. (2012) is consistent with findings made by Mudd (2010) who observed that mining industries in Australia contribute to the emission of GHG and hence climate change. Publications from the International Council on Minerals and Metals (ICMM) have also corroborated the results of Mudd (2010). Hodgkinson et al. (2010) have observed that most of the research that discusses the contribution of mining to climate change has actually focused on what can be done to reduce the impact of mining on climate change rather than assessing the actual impact.

Theme 3: Policies and industry practice in response to the mining and climate-change relationship

As shown in Figure 9.1, out of the eight articles or reports identified, none of them was from Ghana or other mineral-rich country in sub-Saharan Africa. The articles on this topic extracted were mainly from Latin America, Canada or Australia. Their main thrust was the examination of how government policies at the country level were responding to international policies and instruments, such as the Kyoto Protocol and the Paris Agreement and how such policies were shaping the mining and climate-change relationship. It also discussed how the mining industries in these countries were responding to these policies.

Ghana is a signatory to the Kyoto Protocol and the Paris Agreement, as part of its commitment to these agreements, it is expected to formulate and implement a national policy towards the reduction of emissions of GHGs. It is interesting to note that Ghana's National Mining and Mineral Policy, launched in 2014, contains some provisions on mining and climate change. However, its Greenhouse Inventory

Report, as well as its Intended Nationally Determined Contributions under the Kyoto Protocol, as well as the Paris Agreement, do not factor in the contribution of gold-mining operations to the GHG emissions. Hence, as a result of this policy incoherency, mining companies under the umbrella of the Ghana Chamber of Mines have not formulated policies to respond to the climate-change and mining relationship.

Theme 4: Intersecting impacts associated with mining and climate-change interactions

Peer-reviewed articles in this thematic area examined papers that discussed issues that have linkages with the mining and climate-change relationship. For example, hydrological changes and acid mine drainage, among a host of environmental incidents, may have an impact on mining and climate-change interactions, which may affect either the physical or the human environment.

As shown in Figure 9.1, ten peer-reviewed articles and reports were extracted for this paper discussing other environmental impacts that intersect with the mining and climate-change relationship. It is interesting to note that none of these scholarly articles or reports was based on studies conducted in Ghana or other sub-Saharan Africa mineral-rich countries. According to authors such as Philips (2016), Anawar (2013) and Foulds et al. (2014), mining-induced environmental challenges like deforestation and high evaporation could cause variability in rainfall, like excessive rainfall in mineral-rich communities, which could result in the flooding of a mine site due to significant changes in the hydrological cycle of the area. Flooding of a site could also result in the collapse of tailings dams, leading to spillage of toxic mine effluent, contaminating water bodies and the environment.

Philips (2016) and Anawar (2013) further draw a correlation between acid mine drainage and changes in the average temperatures of an area, which could be attributed to climate change. While Rayne et al. (2009) has argued that, based on the results from water runoff at active and inactive mine sites under different climatic scenarios, these runoffs have the tendency to contaminate both surface and groundwater. This line of thought is also shared by Singh et al. (2010).

Two intersecting issues between climate change and mining that have been investigated by other scholars include (i) the effect of varying climatic factors such as temperature and soil moisture levels on the degree of soil contamination and survival as well as rate of reproduction of soil micro-organisms like *Enchytraeus crypticus* (Gonalez-Alcaraz et al., 2015; Barmentlo et al., 2017; Hancock et al., 2017) and (ii) the effect of climate change and mining on biodiversity (Beggs, 2012; De Laender et al., 2012). In terms of human impact associated with mining and climate-change interactions, the following scholars were found to have a strong association between the effect of the two: Edwards (2014); Birch (2016); and Bebbington et al. (2015). The effect of mining on climate change resulted in a lot of social unrest in some mineral-rich countries like El Salvador.

Theme 5: General perceptions and responses to mining and climate-change interactions

Of the seven peer-reviewed publications or scientific reports extracted for this paper, none of them discussing the general perceptions and responses of stakeholders (such as regulators, government officials, mining companies, the media and civil society organisations, as well as residents of mining communities) with regard to mining and climate-change interactions was from sub-Saharan Africa. This observation goes to buttress the earlier point about a lack of data on mining and climate-change interactions in mineral-rich sub-Saharan Africa countries. Odell et al. (2018) underscore the difficulty associated with this type of study to assess public perceptions and responses about mining and climate-change interactions. This could partly explain the seeming lack of information on this topic.

According to Odell et al. (2018), this type of study takes place in a free democratic society where media pluralism is at its peak. For example, as noted by Kronenberg (2013), the removal of 40 million cubic feet of ice glaciers in Kyrgyzstan to pave the way for the mining of gold deposits did receive public protest, as against another attempt at 800,000 cubic feet of glaciers between the Chile and Argentina border to mine gold deposits, which received much public outcry with the issue having to be settled at the law courts (Urkidi, 2010; Carle, 2015). Scholars such as Ford et al. (2010) and Loechel et al. (2013) have argued that there is a disconnection between the perception and response of officials from mining companies and government officials as to the actual impact resulting from mining and climate-change interactions and that of the larger society. This disconnection affects the way and manner in which public policies and industry practices are implemented to address the impacts as well as influence the political economy within which mining takes place in mineral-rich countries.

Lesson from Latin America, Canada and Australia

There is a lesson to be learnt on understanding the nexus between mining and climate change from gold producing countries in Latin America, Canada and Australia. Furthermore, other mineral-rich countries, especially those in Latin America, which are faced with the aforementioned concerns have taken bold decisions or given an indication of their intention of halting mining operations to address their impact on the environment. A typical example of such mining-dependent countries that have given such strong indications are El Salvador and Chile. For example, the *New York Times* (Palumbo & Malkin, 2017) and the *Guardian* (Lakhani, 2017) carried a news item noting the banning of mining in El Salvador amidst the fear of climate change and its associated devastating impact on water resources. The law was passed as a result of several years of scientific studies that highlighted the risk of the country's water resources being depleted due to climate change. To allow mining to take place within the context of global climate change would seriously affect access to clean water (Broad & Cavanagh, 2015; Spalding, 2003; Moran, 2005).

Furthermore, other scientists reviewing El Salvador's strategic environmental assessment report for the mining sector argued that the mining industry was likely to use all available water resources through climate change, thereby making El Salvador a water-scarce country. These scientists further argued that extreme events, such as high rainfall, might increase surface runoff, which could cause flooding and affect the structural integrity of the tailings or destruction of key mine infrastructure. The overall result of such effects could be significant contamination of existing scarce water resources as well as making it practically impossible to mine and extract gold, thereby reducing the ability of the mine to produce gold (TAU, 2011; Bebbington et al., 2015).

Anecdotal evidence from Chile quotes a mining executive of a major mining company saying that mining companies operating in Chile should undergo "socio-technical changes", not as an adaptive response to climate-related pressures on the country's water and energy resources, but as a way of gaining legitimacy in the context of climate change. This view was also shared by officials in charge of the regulation of the mining industry; that is, in the future, mining companies operating in Chile would be assessed based on their climate-change footprints (Odell et al., 2018). It could be inferred that, in El Salvador, there exists a few studies that highlight the relationship between climate change and mining, which were used to influence policy decisions. However, in the case of Chile, there were a limited number of studies on this subject to guide policy formulation and implementation.

As noted by Odell et al. (2018), at the global front, discussion on the relationship between climate change and mining has not received much attention in the scientific literature. The authors argue that, in sub-Saharan Africa countries, especially gold-rich countries in West, East and Central Africa, the situation may be a little difficult although the mining industry is seen as a major driver of socio-economic and political well-being of these countries. It has also been noted to be a contributor to deforestation and the release of GHGs, causing climate change in these countries, as well as the pollution of air, water bodies and land degradation.

A similar study by Tost et al. (2018) to evaluate environmental pressures associated with the mining industry suggest non-availability of data on the mining industry from major institutions that have the power to provide accurate information about the industry at the global front. The authors argue that mining data providers such as the US Geological Survey (USGS), the British Geological Society, World Mining Data and S&P Global Market Intelligence do not include data on environmental performance of the industry in their reports but rather only economic and production data are shared in their annual reports. Data on the impact of the mining industry on global emissions of carbon-dioxide emissions or other GHG gases are virtually non-available.

Authors such as Christensen et al. (2011), Muenstermann (2012) and Irarrazabal (2006) have all been very critical about the Australian government's decision to encourage the exploitation of coal mining in the country. The rationale for their criticism was based on the fact that the promotion of coal mining may lead to an increase in emissions of carbon dioxide and other GHGs. The authors concede however that coal mining has huge economic potential for the country's finances.

In the study by Ostojic (2015), examining the responses of Chilean mining companies to government policies towards reduction of emission so as to address the issue of climate change in the country, observed that most of the mining companies had developed a new pump to improve the companies' energy efficiencies and at the same time reduce their carbon emissions.

While in some mineral-rich countries mining companies are responding positively to government policies aimed at halting the negative impact of climate change, those in South Africa are not willing to respond to the changes that climate change brings to the mining sector (Mzenda & De Jongh, 2011). Similarly, mining companies in Australia, though acknowledging the threat of climate change on their operations, are not prepared to change their mode of operations as a way of responding to national policies. Instead, they prefer to use their public-relations strategies to secure the needed social licence for their continuous operations (Pellegrino & Lodhia, 2012).

Conclusion

This paper has sought to assess the nexus between climate change and mining in sub-Saharan Africa using Ghana as a case study. It was divided into two parts, with the first part providing anecdotal evidence to back the claim that the mining industry in Ghana is contributing to climate change. This type of analysis was backed by satellite images, as well as rainfall values for the moist deciduous evergreen tropical rain forest, where most of Ghana's rich mineral deposits are found. The result from this type of analysis revealed that mining has resulted in the significant destruction of the forest cover, contributed significantly to the emission of GHGs, such as carbon dioxide. The overall cumulative effect is the reduction in rainfall values in this agro-ecological zone of Ghana.

The second part of the paper undertook a systematic review of the existing literature of the mining and climate-change interaction, with a view to assessing the current state of knowledge on this subject in sub-Saharan Africa mineral-rich countries. This type of review is necessary because there is prediction that most of the countries in sub-Saharan Africa will experience severe impacts of climate change.

The paper adopted a framework developed by Odell et al. (2018). This systematic review found the framework useful in helping to organise existing knowledge on this subject into six thematic issues. It emerged from the analysis that there is a yawning gap in the literature over the mining and climate-change interaction; out of the 32 articles extracted for this review, only 3 were based on experiences of the mining and climate-change relationship in sub-Saharan Africa. It also emerged that there were no articles that sought to understand the political and economic conditions under which the mining and climate-change relationship should be discussed as well as the perceptions and responses from the different stakeholders on this subject matter.

Finally, this paper concluded that climate change would have devastating impacts on economies of most countries in sub-Saharan Africa, which depend on mining. Every effort should be made to factor in climate change in any decision to mine or not mine.

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10
Extractive Industries and Low Carbon/Resilient Development in Madagascar

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Abstract

Madagascar is rich in natural resources. It is also a victim of the evolving impact of climate change. In Madagascar, the extractive industries and climate change influence each other in various ways, as explored in this article. The impact of extractive development methods is examined in the light of the change in climatic parameters observed in the country. Greenhouse gas emissions generated by the extractive sector are considered the most impacting threat to climate change. The threat has notably been associated with mining rushes in protected areas, water and air pollution, and various environmental and socio-economic consequences. However, climate change also affects the extractive industries, notably by increasing the costs of investment in the sector as well as complicating the financing of fossil-fuel projects, creating, for example, a global aversion to mining coal. This study demonstrates the urgency for Madagascar to make a radical shift towards improving its mining and environmental policies. These policies should be combined in an integrated manner

to move towards a resilient and beneficial development for both local populations and the national economy. The article recommends the adoption of a low-carbon development path, as well as a proactive approach to climate change adaptation. Implementation of these recommendations would induce concrete actions by public authorities and actors in the extractive sector towards more resilient development.

Introduction

Africa is more vulnerable to climate change than any other region of the world (Richard, 2019). From 2015 to 2020, for example, the 16 countries of the Southern African Development Community experienced extreme weather shocks, including erratic rainfall, flash floods, droughts and devastating cyclones, affecting nearly 45 million people (World Food Programme, 2020. The population's capacity to adapt to climate change remains low due to infrastructure problems and a lack of social services and food security (World Food Programme, 2020). Yet, the African continent abounds in a multitude of natural resources that can be exploited to address these problems, especially the issue of food security. Indeed, out of the 81 countries rich in extractive resources (World Bank, 2018), 20 of them are in Africa, and they hold 30% of the world's mineral reserves, 10% of oil, and 8% of natural gas (Charlotte & Lundgren; Alun & Thomas; York, 2013).

The extractive industries could have an increasing influence on the earth's climate and temperature, attributable to industrial processes that require large amounts of energy. Furthermore, climate change could also impact extractive activities in terms of capital and operating costs (Dourlens, 2015). However, the linkages between climate change and extractive industries are not yet well established in terms of the implications for sustainable development and climate change mitigation, making it difficult for decision-makers to integrate them into their policy and strategic decision-making.

Countries rich in strategic minerals and metals, such as SADC member countries, hold an important place in the climate-friendly global energy transition, thanks to their large reserves of nickel, copper, cobalt, and rare earths, etc. Madagascar joined the Southern African Development Community in 2005 and became a full member in 2006.

The "Big Island" has a large potential in non-renewable natural resources, namely, mineral reserves, hydrocarbon and gas resources. In 2018, the contribution of the extractive sector to Madagascar's gross domestic product (GDP) was 4.41% (EITI Report, 2018). In the mining sector, Madagascar produces nickel, cobalt, ilmenite, graphite, chromium and gold. On the other hand, in the upstream hydrocarbons sector, oil exploration is concentrated in the West Coast basins. Specifically, on this part of the big island, the US Geological Survey (USGS), in its April 2012 assessment, estimated for the Morondava reservoirs a potential of 10.7 billion barrels of oil, 167.2 Tcf (Trillion cubic feet) of natural gas and 5.2 million barrels of liquefied natural gas.

The transition to a low-carbon energy system requires the extraction of strategic minerals and metals for applied technologies in renewable energy and high technology. This situation could lead to a paradox as the quest for energy independence may create pressure to increase industrial, artisanal mineral production. This would have an impact on Madagascar's biodiversity, renowned for its high level of endemism, and its climate would be exposed to extreme variations due to climate change.

Aware of these issues, the Malagasy Civil Society Organisations Platform on Extractive Industries (OSCIE),[1] whose mission is to work for the good governance of mining and oil and gas resources, proposes in this study to catalyse an in-depth reflection by relevant sector players on the relevance and feasibility of the development of extractive industries for a low-carbon. It further calls for resilient socio-economic development in the country, taking into account the global challenge of climate change. More specifically, this study aims on the one hand to identify the elements of risks and vulnerabilities of the extractive sector to climate change, and on the other hand, to explore the challenges and opportunities that the sector faces with respect to climate change.

The methodology of this study focused on secondary research to draw on existing literature on the subject, and on the voices of experts.[2] This article is divided into three main parts illustrated by case studies. First, the development methods used within the Malagasy extractive sector and the current and future parameters

1. OSCIE brings together twelve entities active in the promotion of good governance in the extractive industries sector, namely, the Alliance Voahary Gasy (AVG), Blue Ventures, CRAAD-OI, Durrell, KMF/CNOE, the ROHY movement, SAF/FJKM, Solidarité des intervenants du foncier (SIF), TAFO-MIHAAVO, the TARATRA project, Transparency International – Initiative Madagascar (TI-IM) and WWF.

2 Given the global health situation related to Covid-19, the surveys and interviews are difficult to carry out because of state measures limiting movement within the country.

of climate change in Madagascar are presented. Then, the impacts of the extractive sector on climate change are analysed. Finally, the impact of climate change on the extractive sector is presented followed by recommendations for the development of a resilient extractive model that promotes low-carbon development.

The extractive sector and climate change in Madagascar

In the twentieth century, the Malagasy extractive sector was dominated by small-scale and artisanal mining, both open-pit and underground. Mining operations, regardless of their size, generally take place in regions that are difficult to access or are landlocked. Operators used unconventional and rudimentary methods. Following reforms in the legal and institutional framework in the 2000s, large foreign companies set up operations using modern and industrial extraction methods. As an anthropogenic activity, extraction methods, whether artisanal or industrial, impact the ecosystem and contribute directly or indirectly to climate change. What are the mining and oil resource extraction methods used today in Madagascar? And what is the state of climate change in the country?

Extraction development methods

Gold mining and processing techniques in small-scale and artisanal mines

Artisanal mining is done by digging holes or trenches rarely exceeding a few metres in depth, generally without prior stripping, and with the uprooting of large trees. The overburden[3] or barren land is often piled up near the holes or trenches (Guidici P., Rabemananjara, 2012). The process includes various steps, such as crushing, washing, filtration, sorting, grading, magnetic separation, under-pressure oxidation, flotation, leaching,[4] concentration by gravity and pelletising or sintering, and briquetting or nodulation (agglomeration).

3 Layers of earth and rock overlying an ore deposit. Overburden is removed prior to open pit mining and should be replaced after the metal ore is extracted from the ground.

4 The process of leaching (or washing) with a solvent or slowly passing a solvent through a suitably pulverized and thickly deposited product to extract one or more soluble constituents. In mining operations, it is the chemical dissolution of certain constituents of a material, used to extract metals, valuable minerals from an ore.

The mineralised layers are extracted and then washed either directly in the extraction holes, when the water table is high, or are transported in baskets or bags or other rudimentary containers to natural water points, or artificial ones near the water points, and filled by digging a small channel and by pumping. The washing is done in sieves often made by hand from a sheet of metal plate pierced with a spike and hammer. The washing water, containing a high proportion of soil, is left on site (Guidici P., Rabemananjara, 2012).

Fig 10.1. OSCIE, April 2020, extract Betsiaka area data base.

Mining operators can generally choose the processing (or beneficiation) methods to concentrate the desired metals in the metal ore they have mined. These methods affect the environmental components of operating sites differently; some have more severe impacts than others. For example, cyanide leaching5 of gold ore has more potential to contaminate the environment than gravity gold concentration (United States Environmental Protection Agency, 1995). Malagasy gold deposits are exploited by different national and foreign operators using various methods that will be briefly reviewed. Artisanal mines are set up without any concern for environmental impact.

Exploitation of eluvial and alluvial deposits

For eluvial deposits, national gold miners dig galleries or trenches to follow the gold-bearing quartz vein. The depth of the gallery, dug with spades and picks, varies according to the speed of the vein. The gold-bearing eluvial rock fragments are crushed by hand using hammers. For alluvial deposits, or gold placers,[6] mining operations are carried out either in the live riverbed by diving to recover the alluvium[7] using the long-handled or short-handled shovel, depending on the depth of the river water, or on the river banks by digging shafts. The shafts could either be shallow to obtain the alluvial ores, or slightly deeper to reach the gold gravel. The mining operators use artisanal winches. Placer mining is environmentally destructive because it releases large amounts of sediment that negatively affect surface water several kilometres downstream from the mine (Environmental Law Alliance Worldwide, 2010)

Subsequently, the gold miners generally proceed by washing the raw ore[8] extracted from the alluvium or crushed rocks and gravel with river water by panning to obtain pre-concentrated ore. After a certain settling time, the miners recover the gold in the pre-concentrate by hand (gravity concentration). Often, they burn the products, which they call white gold, in a small metal plate, in the open air over a wood

5 Cyanide leaching is a relatively inexpensive method of processing gold ores and is the main method in use. In this technique, the cyanide solution of sodium or potassium is either applied directly to the ore in open heaps or mixed with a fine ore pulp in vats; heap leaching is generally used to recover gold from low-grade ores, while vat leaching is used for higher-grade ores.

6 A deposit of sand and gravel containing precious metals such as gold, tin, and diamond, is so-called alluvial placer.

7 Relatively recent deposits of sedimentary material found in river beds, major riverbeds, lakes, or at the base of mountain slopes (alluvial adjective).

8 A naturally existing material from which a mineral or minerals can be extracted (ilmenite = titanium ore, titanium = mineral).

fire to transform the gold to its natural colour. Gold miners mainly use rudimentary equipment such as spades, pickaxes, hammers, panning, and sluices.[9] They do not wear any personal protective equipment (gloves, boots or masks) during their work.

Exploitation of veins

For in-place deposits or veins, or for the exploitation of hard rock, the exploitation technique consists of drilling vertical shafts, in alignment. It is characterised by an almost perfect alignment of small vertical circular shafts crossing the overburden or barren land, to reach the mineralised layer with artisanal afforestation and support techniques. Ore can be extracted from the walls of these small shafts, or from narrow tunnels following the direction of a gold vein, or from trenches of various sizes. They generally use picks, shovels, excavators, hammer drills and dynamite. Ropes and buckets may be used to bring the ore to the surface, from where it is transported in bags. The waste rock is often dumped on unmined surfaces or in nearby shafts (Seydou, 2001). When the depths of the veins exceed the level of the water table, water control becomes an essential task for the operators who are faced with either dewatering for the extraction of the ore or having a shortage of water during the processing phases.

In the live riverbed, mine operators use floating dredges with buckets instead. They excavate the gravel layers that will be dumped into sluices where they deposit mercury bubbles for amalgamation. The gold pellets will be recovered by the dredger itself and will be burned in open air using a blowtorch, where the mercury escapes in the form of vapour. They can also be burned in a retort, which recovers part of the mercury vapour (generally around 80%, but subject to variations) to transform it back into a liquid that can be reused. River water is used to wash the gold-mercury amalgam product. The waste water is discharged directly into the river (Ministère de l'Environnement, de l'Ecologie et des Forêts, 2018).

Mining operators also extract gold by chemical leaching or washout, including cyanidation. Cyanidation consists of dissolving the gold contained in the ore by adding cyanide and water to the crushed ore to obtain a water-soluble gold-cyanide complex. The gold-cyanide complex is then absorbed on activated carbon. This

9 The sluice or washing ramp is a channel or set of inclined planes, usually made of wood, lined with carpet or rugs and cleats, through which the gold-bearing alluvium is passed to extract the gold.

carbon is burned to obtain gold. Sometimes, the dissolved gold is precipitated on zinc and then the zinc is dissolved with acid to form a gold paste, which is then melted and cast (O'Neill and Telmer, 2017).

The chemical leaching process is the most widely used, since it often recovers more than 90% of the gold and it is inexpensive. Moreover, unlike the mercury process, no persistent pollutants are released. It is a biodegradable chemical compound that can be eliminated. When used properly, it can be safe for human health and the environment (O'Neill and Telmer, 2017).

Heavy oil extraction methods

Madagascar has two large deposits of unconventional oil: the bituminous sandstones of Bemolanga and the heavy oil of Tsimiroro. The latter, with an approximate surface area of 6670 km², is administratively attached to the rural Commune of Ankondromena in the districts straddling the regions of Melaky and Menabe, where a project for the extraction of hydrocarbons is underway. Previous work has revealed a reserve of about 1.7 billion barrels in place for a recoverable volume of about 1.5 billion barrels (Ecofin Hydrocarbons Agency, 2014). The depth of the reservoir layer is between 40 and 300 metres underground. The promoter of the pilot plant has undertaken significant work since 2004 to produce a certain amount of oil from this deposit. Plans are underway to develop this project for exploitation on a larger scale (Andriamaparany, 2014).

The in situ steam[10] injection extraction process is selected to produce heavy oil in industrial quantities. The operators proceed first by drilling injection wells. Steam injection into the ground consists of heating the viscous oil until it becomes hot enough to flow. This process depends on the steam produced by commercial fuel-fired boilers. In addition, the production of steam requires large quantities of clean water, most of which can be recycled, especially for this in situ process, which requires intensive treatment systems.

This process is an increasingly common method of extracting heavy crude oil. It is considered as an enhanced oil recovery (EOR) method and is the main type of thermal stimulation of oil reservoirs. There are different technologies in use, the two

10 Steam injection is widely used in the San Joaquin Valley in California (United States), in the Lake Maracaibo region of Venezuela and in the oil sands of northern Alberta (Canada).

main ones being cyclic steam stimulation and steam flooding. Both are most often applied to oil reservoirs that are relatively shallow and contain highly viscous crude oil (the case of Tsimiroro), at the temperature of the underground formation.

Technically, one of the main advantages of this thermal method – steam injection – is that it effectively reduces the viscosity and mobilisation of the heavy oil. The main disadvantages associated with these heavy oil[11] steam recovery methods include the high greenhouse gas footprint, the low recovery of heavy oil (heavy oil or bitumen), the difficulty of shutting down operations under emergency conditions (Ali & Chen, 2019), and their high consumption of water and energy.

Unconventional exploitation, through water steam injection or other techniques, raises many environmental, social and economic issues. With a production rate of 180,000 barrels per day over a period of more than 30 years (Wykes & Quero, 2013), as proposed by the proponent, the impacts of this project on the surrounding ecosystem will be quite significant, for an area that is already experiencing water stress under normal conditions. Because of the special conditions it requires, this development will have a considerable human, social and environmental cost and will cause greater harm than conventional oil would. In particular, it raises questions about the significant water needs, the vulnerability of water resources (ground and surface), and the rehabilitation of drilling sites (post-mining) without excluding concerns for social acceptability and health risks (Association Initiative pour la recherche économique et sociale en Afrique sub-saharienne et les amis de la terre, 2012).

1. Changes in climate parameters observed in Madagascar [12]

Almost every year, the north-western, northern, and especially the north-eastern part of the country are often directly affected by natural disasters (cyclones and storms). In January-February 2018, for example, these areas received up to 400% more rainfall than the seasonal standard. The sectors that are most affected by flooding are housing, agriculture, education and roads. The severed roads and bridges have

11 Cyclic Steam Stimulation (CSS), Steam Injection or Steam Assisted Gravity Drainage (SAGD)

12 According to the Météo Madagascar, CPGU (Cellule de Prévention et Gestion des Urgences), RIMES: [global presentation of the effects of climate change on the ecosystem in Madagascar, what the IPCC report says, the measures taken by the successive regimes [the conventions signed, Madagascar's participation in the COPs, the projects in progress and already closed and their results].

slowed relief efforts and increased the cost of humanitarian interventions (Direction Générale de la Météorologie and Regional Integrated Multi-Hazard Early Warning System - RIMES, 2019).

Paradoxically, annual rainfall is declining in most places in Madagascar, particularly in the eastern and south-eastern parts of the island. This downward trend is small compared to the very high annual variation in rainfall. In terms of seasons, rainfall in summer shows a decline compared to the rainfall in winter. The number of days with extreme rainfall in one day is generally decreasing.

Maximum and minimum temperatures increase respectively to 0.04°C/year and 0.05°C/year in Madagascar. Maximum temperatures show an upward trend of +0.23°C/decade on an annual basis. The hot and humid season shows an increase of +0.20°C/decade. In winter, the maximum temperature trend is +0.25°C/decade (Direction Générale de la Météorologie RIMES, 2019).

The sea temperature in the Western Indian Ocean (Kenya, Mozambique, Tanzania, Madagascar, Reunion, Mayotte, Comoros, Mauritius and Seychelles) increased by 0.60°C between 1950 and 2009. The sea level in Madagascar varied by 1.57 mm/year between 1993 and 2017, which is lower than the global rate of 2.87 mm/year.

No trend has been observed regarding the frequency or intensity of tropical cyclones in the southern Indian Ocean region, of interest for Madagascar, based on existing studies.

Concerning future climate change to be experienced by the country, two different scenarios of future greenhouse gas emissions, relating to the “moderate” (RCP[13] 4.5) and “high” (RCP 8.5) scenarios are considered. Precipitation is projected to decrease in the 2030s and 2050s. In particular, winter precipitation from July to October could be affected by a larger deficit. The daytime maximum and night-time minimum temperatures are likely to increase. The sea surface temperature is expected to increase in the southern Indian Ocean. Therefore, a similar effect is likely on the sea water around Madagascar. The frequency of tropical cyclones is not expected to change much, while intense tropical cyclones are expected to increase. The likely sea-level rise is estimated at 0.28 to 0.48 m in 2100 (Météo Madagascar, CPGU).

13 RCP = Representative Concentration Pathway.

The impact of the extractive sector on climate change

The extractive sector impacts climate change in many ways, including through greenhouse gas emissions associated with land use and land-use change, and those associated with the energy sector.

GHG emissions in Madagascar

In Madagascar, the main greenhouse gas (GHG) emitted during the 2005 to 2010 period is CO_2. N_2O came in second place followed by CH_4. The contribution of CO_2 and N_2O emissions varied respectively from 82.6% to 83.6% and 9.3% and 9.7% while CH_4 emissions fluctuated between 7.2% and 7.5% during these five years. Among the precursors or indirect GHGs, carbon monoxide (CO) remains the main GHG emitted. Non-methane volatile organic compounds (NMVOCs) and nitrogen oxides (NOX) and SO_2 are also among the indirect GHGs that have increased.

During the inventory period from 2005 to 2010, the land use and land-use change (LULUCF) sector contributed to the majority of emissions, at around 82%. It was followed by the agricultural sector, with almost 16% in 2010. This is explained by the fact that wood is the main source of energy in the country and agriculture plays a dominant role in economic activities. The energy sector is responsible for 2% of national emissions, while the industrial processes and waste sectors contributed only about 0.4% of national emissions.

In the energy sector, the national transportation and residential subsectors contributed to the majority of the emissions. The agriculture sector includes emissions from crops and livestock; livestock, through enteric fermentation and manure management, combined with emissions from agricultural soils and paddy rice cultivation, which are the main contributors. Concerning the LULUCF sector, between 2005 and 2010, Madagascar remained a net GHG sink. However, its sink capacity has decreased mainly due to a decrease in absorption; absorption in forest lands has fallen, while wetlands seem to have changed role from being a sink to an emitter. (***Source:*** *Excerpts from the Third National Communication to the United Nations Framework Convention on Climate Change, October 2017.*)

Extractive Industries and GHG Emissions Associated with the LULUCF Sector

As presented in the section on extraction methods in Madagascar, forests and water resources are the components of the environment, under the LULUCF[14] sector, likely to be most affected by mining activities. This includes, in particular, forest lands and wetlands.

The disposal of mining products very often requires the clearing of forest and vegetation areas. The fragmentation of these ecosystems leads to the isolation of certain species. This isolation can lead to a decline in local species and a loss of natural resources. Furthermore, the passage during transport of products, in or next to protected areas, leads to a fragmentation of natural habitats with various effects on fauna and flora.

This is all the more alarming when one considers that the country has a unique biodiversity that needs to be preserved in its protected areas; these cover nearly 11.9% of the territory (or 7 million hectares) (Vyawahare & Lemarie, 2020). Furthermore, the restoration of natural forests and the strengthening of habitat connectivity, as well as the development of climate refuge areas inside and outside protected areas, are among Madagascar's priority actions for adaptation to climate change.

The ore treatment or beneficiation process generates large volumes of waste called *tailings* or *heaps* that may contain quantities of hazardous toxic substances, such as cyanide, arsenic, lead, cadmium and chromium. The extraction of a few hundred million metric tons of ore will generate a similar quantity of tailings or heaps. These tailings are generally discharged into water bodies, resulting in the contamination of surface and groundwater (UNEP, 2013). The impact of the deposition of these tailings[15], as well as rock waste and heap-leaching on water quality, can be severe and are a serious concern for local communities. This is because over the long term, the toxic substances deposited may eventually dry up these water bodies. Sometimes, the dry tailings are used as fill (Persaud & Telmer, 2015).

14 Land use, land-use change and forestry (LULUCF) is a category used in sectoral greenhouse gas emissions inventories that aggregates greenhouse gas emissions and removals resulting directly from human activities related to land use, land-use change and forestry.

15 Gold miners do not use tailings settling ponds.

Impact of mining rushes on protected areas

With Madagascar's wealth of natural resources, artisanal mines, or "quarries," operate all over the island. Small-scale miners yearning for precious stones, and human rushes from various parts of the country – often motivated by the hope of a rapid improvement in living conditions – are common phenomena.

The mining methods used by the small mines undermine the integrity of the island's ecosystems. From north to south, east to west, the environmental disasters left by these artisanal mines are significant in the country's protected areas. The influx of people into the mines weighs heavily on natural resources; it exacerbates pressure on soil, water and forests, and also leads to sanitation and waste-disposal problems. The latter are sources of contamination of various resources, mainly water. These impacts could subsequently affect local economic activities, such as agriculture, rice cultivation, and fishing. These disturbances may extend beyond the mining area. Impacts on water use and access are one of the most contentious aspects of mining projects, often creating tensions between mine operators, migrants, and local communities.

Mining rushes in the north of the country

In the north, the gold and sapphire sector is an example of the case of mining in the Diana region. More than 25,000 mining operators (Arson, 2017), both local and migrant, are invading Betsiaka.[16] Gold mining in this commune is essentially artisanal. Among the ten best known mining sites in the Betsiaka region, the Ambilo and Andavakoera deposits (Estelle Levin & WWF, 2012) are located in a protected area managed by the NGO Fanamby (Arson, 2017).

16 The rural commune of Betsiaka is located in the District of Ambilobe, in the Diana Region, in the extreme North of Madagascar. Served by the RN5A road from Ambilobe, the road is only pass able in the dry season, leaving the commune landlocked and very difficult to access in the rainy season. The local population makes a living from three main activities: livestock, agriculture and gold mining, which is carried out occasionally or intermittently and informally.

Table 10.1. Number of gold miners and production. *(**Source:** Daily production of gold miners according to the September 2016 census in Betsiaka, conducted by PAGE/GIZ).*

Number of gold miners	Minimum production (Dg)	Maximum production (Dg)	Average production (Dg)
900	0 to 0.5	2 to 15	0.456 to 4.120
3536	0.6 to 1	2 to 20	1 to 3.74
1136	1.1 to 2	2 to 10	2 to 4
193	2.5 to 5	3 to 10	2.5 to 5
Global	0 to 5	1 to 20	1.2 to 4

Out of the 14,371 gold miners registered in Betsiaka in 2016, only 368 – or 2.56% – had a professional card issued by a competent authority.

In the gold-mining value chain, the processes undermine the integrity of the soil because artisanal miners still carry out clearing and excavation. In addition, gold miners work on prohibited sites, namely the Tany Miasa or agricultural area, or the Tany Maty or erosion areas (Arson, 2017).

The case of sapphire mining in Ankarana in northern Madagascar is also interesting. Ambondromifehy and Andranonakoho, villages close to the special reserve of Ankarana, are invaded by migrants for sapphire mining. This has mainly been done in the Ankarana Park since 1996, which has accelerated the destruction of the vegetation cover by logging, and the disfiguration of the environment and soil. This is all the more damaging since, beyond the destruction of ecosystems, it is an important tourist site considered sacred by the Antakarana (Arson, 2017).

Mining rushes in the east of the country

Although exploitation in a protected area is a crime (Mining Code, 2005), the case of Ankarana is not an isolated one. The Ankeniheny-Zahamena ecological corridor in the Alaotra Mangoro region suffered the consequences of the gold and sapphire rush. The Ankeniheny-Zahamena corridor is located near Didy (Ambatondrazaka) a large sapphire quarry. The exploitation itself has had no less impact on the daily lives of the inhabitants. One example is the impact of the exploitation processes on water.

It has become muddy and undrinkable. The excavated areas end up becoming holes, then tunnels, which are sometimes very deep, even reaching the aquifer.[17]

Mining rushes in the south-west of the country

The craze for sapphire is not without risks, as it gives rise to numerous occupational accidents in places where digging wells is necessary. In addition, there is the development of diseases and outbreaks due to a lack of hygiene, the harsh climate, and a lack of protection against dust, as well as the consequences of the absorption of drugs and other stimulants (Symphonis, 2006). Juvenile prostitution and the proliferation of sexually transmitted diseases have increased, and access to basic healthcare infrastructure has long been problematic (Prostituée, Madagascar Ilakaka, 2015). Furthermore, the massive influx of people into Ilakaka – an area without any community infrastructure, waste/wastewater management or sanitation – for sapphire mining has led to a significant ecological imbalance. The ecosystem has been affected on all fronts (landscape, soil, water, flora and fauna), with the landscape transformed into a messy pile of barren land, crushed rocks and detritus of all kinds (Symphonis, 2006).

Fig 10.2. OSCIE, September 2018, damage caused by the mining rush.

17 De Grave A. (2017, août 09), qu'arrive-t-il après un boom minier ? Photographies à Madagascar, mongabay.com, consulté le 06 juin 2020 sur : https://fr.mongabay.com/2017/08/quarrive- t-il-apres-un-boom-minier-photographies-a-madagascar/#:~:text=La%20ru%C3%A9e%2C%20l'argent%2C,plus%20tard%2C%20le%20cycle%20recommence

Land stripped by digging holes wrecks corrupts the productivity of soils that are already exhausted from erosion and drainage. Mining waste after washing ore increases the sediments deposited in riverbeds, leading to a progressive degradation of water quality (Symphonis, 2006). Mineral extraction methods release fugitive dust that distorts the vegetation cover. The increased demand for fuel (coal) is accelerating rampant deforestation throughout the region. Poaching of wild animals has intensified.

Moving further south, in the Atsimo Andrefana region, the impact of small mines on the Zombitse Vohibasia park continues. This park located 20 km from Sakaraha plays an important role in ecotourism and scientific research thanks to the endemicity of its fauna and flora. Human activities (logging and mining) threaten its ecological balance and also endanger the development of sustainable ecotourism (Soilihi, 2006).

Impacts of gold mining activities on aquifer system

Soil erosion, sedimentation, pollution

Gold mining activities have caused soil erosion phenomena for many years. Once soil is eroded, it is difficult to reconstitute the vegetation on the slope, either naturally or with human assistance. Furthermore, soil erosion is a major concern in view of the large areas of land damaged by mining and the large quantities of material spread over mining sites. Erosion causes significant loading of sediments with accompanying chemical pollutants to nearby or downstream water bodies. Erosion and sedimentation cause the accumulation of thick layers of fine sediment in local floodplains, degradation of aquatic habitats, and loss of storage capacity of water bodies. High levels of suspended solids (non-filterable tailings) and dissolved solids (filterable tailings) in runoff, and bank erosion in watercourses are adverse impacts of water management at gold mining sites. In addition, gold mining involves high water consumption, which weakens other local activities (agriculture, livestock farming, and drinking water consumption) *of* the surrounding communities and the needs of the ecosystems.

Fig 10.3. OSCIE, May 2019, Impact generated by small-scale mining.

Pollution of aquatic ecosystems by mercury

The national inventory of sources of mercury release into the environment in Madagascar in 2016 (MEEF, 2016) found that the use of mercury in artisanal and small-scale gold mining is not negligible. The national synopsis report for this sector in 2017 reveals that Madagascar[18] uses a minimum of 18 tons of mercury per year in small-scale and artisanal mining, mainly in mines operated by foreign gold miners[19]. In its methyl mercury form, which is very toxic, it enters the food chains from aquatic systems on a long-term basis. These changes in water quality not only hinder economic and social well-being, but also the sustainability of vital ecological flows, ecosystems and biodiversity (WWAP, 2017).

In the absence of concrete measures resulting from investigations at the operating sites, the default theoretical factors for the distribution of mercury releases to the environment are retained and are estimated at 0.6 for air, 0.2 for water and

18 To fulfill its obligations under the Minamata Convention, Madagascar has developed, with support from the GEF and UN Environment, this National Action Plan (NAP) to reduce and/or eliminate the use of mercury in the EMAPE.

19 The decree n° 2015-1035, fixing the Gold Regime, stipulates in its article 22 that the use of any chemical process is prohibited in any gold-mining activity. Data collected from INSTAT reveal that Madagascar does not import mercury; consequently, the importation of mercury used by foreigners is illegal and it is impossible to quantify exhaustively.

0.2 for soil, respectively (O'Neill & Telmer, 2017). These authors, by applying this distribution factor in the sites using mercury, were able to calculate for Madagascar more than 11 tons of mercury per year that pollute the atmosphere, and more than 3.6 tons that are discharged into water and soil. This process should be evaluated and controlled. A periodic monitoring system for mercury emissions and releases is provided for in Madagascar's National Action Plan (NAP) for Artisanal and Small-scale Mining (EMAPE).

Impacts of heavy oil exploitation on the surrounding ecosystem

Degradation of the vegetation cover and impacts on the Tsingy de Bemaraha National Park

The operations involved in the heavy oil exploitation consist in clearing trees and bushes on the site beforehand to allow access to the various drilling points and to instal the extraction infrastructures. This may result in significant destruction of grazing areas currently used by the communities, and of vegetation that is already quite sensitive in the area.

That said, the steam injection extraction method is comparatively much less destructive than open pit mining. Particularly downstream of the extraction site, the ecosystem in the areas of influence of the heavy oil project is singularly fragile. Natural reserves next to the deposit area are the main concern, due to the proximity of the Ambohijanahary protected areas and the Tsingy de Bemaraha National Park. The latter, covering an area more than 1,500 km^2, the largest protected site in Madagascar, has been a UNESCO World Heritage Site since 1990, because of its virgin forests, mangrove swamps, rare fauna, and its exceptional karstic landscape of limestone rocks. Despite this wealth, the Tsingy de Bemaraha Park is not well delineated and the reserve itself is poorly monitored. Moreover, the areas surrounding these protected areas (or parks) are places where the local population can exercise their rights to use the forest for harvesting forest products. Consequently, the sustainable management of the resources used is very difficult as the available natural resources could be affected by extraction activities from both a qualitative (contamination, degradation, loss of species) and quantitative (dispersion, trafficking, deprivation, excessive use) point of view. Added to this is an increased demand linked to the sudden influx of newcomers during the exploitation phase, which would compromise use by local communities and exacerbate social conflicts. Subsequently, the population will fall back on the natural resources of the protected areas, thus hindering their sustainable management.

Overexploitation and pollution of aquifer systems

Oil extraction from heavy oil requires huge quantities of water[20]. The heavy oil project area is characterised by significant water variations: the intense aridity of the dry seasons, which can last up to eight months, contrasts with the floods that make access to the area difficult, sometimes even impossible, during the rainy season. The withdrawal of large quantities of water needed for the boilers to produce steam (at very high temperatures) constitutes an overexploitation of aquifers and will generate significant impacts on the region's resources (Association Initiative pour la recherche économique et sociale en Afrique sub-saharienne et les amis de la terre, 2012).

Theoretically, overexploitation[21] of aquifers is achieved when the withdrawal rate exceeds the long-term recharge rate. Groundwater flow will inevitably be reduced. This is essentially a question of the volume of exploitable storage and the sensitivity of aquifers to irreversible side effects during intensive exploitation in the short or medium term.

The Manambaho River is the only major river that flows through most of the communes in the Melaky region. The Tsimiroro project extracts non-negligible water volume from this river for heavy oil exploitation activities in operation or in preparation. In addition to the possible drying up of small streams during dry periods, there is also a high risk of contamination of the water table by potential oil spills and leaks.

The contamination of the water table by heavy oil extraction processes is also a concern. It is about the land-ocean connection through coastal and marine

20 In Canada, for every barrel of oil produced, at least 2.6 barrels of water must be extracted from the Athabasca River, or from local water tables. For so-called in-situ operations, which use steam to separate the oil from the sand in the ground and then pump the bitumen to the surface, freshwater consumption is less, but still significant.

21 Integrating Groundwater Management for Transboundary Basin Organizations in Africa - a training manual produced by AGW-Net, BGR, IWMI, Cap Net, ANBO, and IGRAC" - 2015: the most appropriate definition of *overexploitation* is probably that it is achieved when the overall costs of the negative impacts of groundwater exploitation exceed the net benefits of its use, although these effects are not always easy to predict and/or quantify in monetary terms.

ecosystems. Indeed, the region is characterised by a great variety of geomorphological structures, including the 14,000 ha of the Tsingy of Beankà[22], which extends the Tsingy of Bemaraha[23] to the north.

These landscapes are home to an equally rich and endemic biodiversity. The possible pipelines of this oil project would potentially cross these protected areas for shipping the extracted oil at the port of Maintirano. The pipelines may be subject to technical failures or environmental accidents (landslides) or man-made accidents causing accidental spills and leaks of toxic products into the natural environment, inevitably disrupting ecosystems. During a leak or spill, the components of these toxic products first migrate downwards, and under the effect of gravity, in the unsaturated zone towards the water table. In such cases, the risk of oil pollution of the water table cannot be excluded.[24] Furthermore, the wastewater that gushes from the well after steam injection includes residual formation water, backflow water and water injection fluids (MDDEFP & BCÉS, 2013) that naturally rises within the pores and cracks of the geological formation.

Extracting the oil above ground produces dirty wastewater stored in wet tailings ponds at the extraction site. The non-recycled quantities would be re-injected underground or stored in these settling ponds. This wastewater would be far too toxic. The water carrying extraction tailings, which is sent to settling ponds, contains small amounts of bitumen tailings, sand, clay, dissolved metals and organic components, including polycyclic aromatic hydrocarbons (PAHs), 16 of which are classified as significant pollutants by the US Environmental Protection Agency (EPA). Of greatest concern are the levels of the major pollutants – cadmium, copper, lead, mercury, nickel, silver and zinc – in water collected near or downstream of the development (Ralston: 2014, 03 février). Thus polluted, the water becomes unfit for consumption.

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22 A landscape - mosaic of sandstone and karst landforms, habitats for species of flora (particularly Pandanceae and Pandanus tsingycola Callm & Nusb endemic in form and configuration of its syncarps) and fauna (birds, etc.) - Callmander et al. - 2013 - Pandanus Tsingycola Callm. & Nusb. (Pandanaceae), a New Species Endemic to Western Madagascar.

23 The Tsingy of Bemaraha, a karstic landscape corresponding to limestone formations with varied geomorphological structures, largely covered by dense dry deciduous forest and sometimes interspersed with savannah. A natural park that shelters rare and/or endangered species of flora and fauna (birds, lemurs, reptiles, etc.).

24 For example, in Wyoming, data compiled in 2010 by the Environmental Protection Agency (EPA) showed the presence of contaminants in 19 of the 37 wells sampled, making the water unfit for consumption. Synthetic organic compounds and petroleum-based compounds such as benzene were found in some wells. In addition, methane was found in 10 of the 37 wells.

The monitoring of water quality in the region is crucially lacking. No wastewater treatment project is in sight. The consequences of such water pollution would be catastrophic for the local populations who live mainly from livestock farming, fishing and gathering. The modification of the hydrological balance would have significant consequences on the cattle industry in particular, since extensive zebu breeding is at the heart of the region's economic activity.

Extractive industries and GHG emissions associated with the energy sector

Energy consumption and GHG emissions in the nickel and cobalt mining industry

The largest active mining project in Madagascar is that of Ambatovy, which operates a nickel and cobalt deposit in the east of the country. According to its Sustainable Development Report (2016), the majority of the energy needs of the Moramanga mine site is supplied by a diesel-powered power plant, consisting of nine generators with an average load of approximately 6 MW. To supply its electricity needs, the Toamasina plant uses three coal-fired boilers coupled to a three-steam turbine power plant. The average load of the plant is about 60 MW. In addition to the steam turbines, the three coal-fired boilers provide process steam for metallurgical production. The process steam produced in the coal boilers, plus the heat recovery boilers in the two acid plants, is supplemented by flash steam which is reused in the process areas. Process steam is generally used to heat the pulp and treat process solutions so that the mill processes run efficiently.

Coal is imported from South Africa. Approximately 40 back-up diesel generators are installed throughout the plant to support essential equipment. In 2016, energy consumption was 528,833 MWh for coal-fired electricity and 63,973 MWh for diesel-fired electricity. Thus, this energy consumption is equivalent to the emission of 0.45 MTeq of CO_2, i.e., nearly 29% of Madagascar's GHG emission reduction ambitions in the energy sector (excluding biomass). In other words, if the Ambatovy Company were to consider substituting its thermal electricity production by the production of electricity from renewable energy, this would be significant in relation to the country's emission reduction efforts and would be in line with the energy transition.[25] In addition

25 CO2 emission factors considered, according to IPCC: 820 g CO2/kWh for the coal-fired plant, and 266 g CO2/kWh for the diesel plant.

to the stated objective of supplying 2 million households between Toamasina and Antananarivo, could the Volobe hydroelectric power plant project promoted by the Axian Group meet Ambatovy's electricity needs, in whole or in part? The project aims to produce 750 GWh per year, while Ambatovy's needs amount to nearly 600 GWh.

In addition, the release of greenhouse gas emissions from transportation is unavoidable in a project of Ambatovy's scale. According to its Sustainable Development Report (2015), Ambatovy has sought to reduce the use of local road traffic as much as possible. The choice of a strategic location for the plant, close to the port of Toamasina, aims to reduce the cost and environmental impact of transporting products in and out of the plant. The pipeline ensures the safety and relatively low environmental impact of transporting ore from the mine to the plant. Most of the energy required to transport the ore pulp comes from the gravity system due to the difference in altitude of approximately 1,000 metres between the mine and the plant site. Ambatovy has a fleet of buses for the transportation of personnel to and from the mine and the plant. This ensures that the cost of transportation is not a burden on local employees, while reducing individual transportation footprints.

At the port level, the Ambatovy Company monitors the unloading operations to ensure that the products brought in do not have any negative effects on the city and marine life in the port area. All imported products are transported by rail from the port to the plant to minimise the impact on the environment and the local community. The transportation of personnel has contributed significantly to their overall impact due to transportation. However, the report points out that they are not able to report on the impact of their expatriate workers' travel to and from Madagascar, but can trace local transport by Ambatovy vehicles, trucks, and the small plane that transports staff between the plant, the mine, and the capital. Thus, in 2015, Ambatovy's estimated transport-related CO_2 emissions amounted to 0.041 MTeq of CO_2, which represents 2.6% of Madagascar's GHG emission reduction ambitions in the energy sector (excluding biomass) (Ambatovy, 2015).Theauthors were unable to verify the effectiveness of these measures. However, reducing the transport that requires fossil energy expenses as much as possible is undoubtedly a good practice to consider for any extractive industries project not only for the associated monetary savings, but also for its reduction of the carbon footprint.

Air pollution in gold-mining activities

Gold mining also contributes to air pollution through the spread of wind-borne particulate matter as a result of drilling holes or trenches, material transport, wind erosion, waste dumps and the opening of access roads; so do exhaust and fuel combustion emissions from stationary and mobile sources. Energy consumption by machinery used in extraction and exploitation operations also causes GHG emissions.

The impacts of climate change on the extractive sector

Mining operations are considered to be a driving force for local development. They play an important role in social and economic growth at the local and national levels. Climate events or changes, including changes in temperature, precipitation and extreme, recurrent and more severe weather events in certain regions of the island, have complex impacts on the mining sector.

The supply of water and energy, essential inputs to mining processes, is likely to face significant constraints. Rising temperatures are exacerbating water shortages in some areas, subsequently handicapping water-dependent mining operations. Operators may also come into direct conflict with communities over these water resources. Temperature change also complicates site rehabilitation. With regard to energy supply, in the event of a change in rainfall or temperature, energy consumption necessarily increases to ensure the potential of mining operations.

During extreme weather events, the health and safety of employees is threatened by exposure to heat-related illnesses, an increase in communicable diseases, and the likelihood of accidents related to rising temperatures. Increased physical and non-physical risks will make the development of mining activities more complicated and project financing more difficult. Thus, climate change affects the efficiency and stability of mining infrastructure and makes site closure practices complex.

Climate change may have serious consequences on the stability and cost of water and energy supplies. By affecting the viability and profitability of mining operations, climate change also impacts the development of communities and regions hosting mining activity. If mining operators operating in areas where climate change exacerbates the vulnerabilities of communities do not adopt proactive approaches to climate change adaptation, their operations will suffer. Obtaining and maintaining a social licence to operate will become more difficult, as well as access to project funding, thus affecting the reputation of the activity.

In addition, two specific risks induced by climate change should be mentioned: the increase in investment costs in the extractive sector and the progressive difficulties in financing fossil-energy exploitation projects. This last point will be illustrated by the case of Sakoa Coal Field.

Rising investment costs in the extractive sector

In the Tsimiroro Heavy Oil exploitation project

The case of Tsimiroro heavy oil is illustrative of the risk of increased investment costs due to climate change. Due to the basic vulnerability (significant water variations and sensitive ecosystems) of the project area, changes in temperature and precipitation, as well as more frequent and severe extreme weather events, complex impacts on the heavy oil extraction project will occur. For this water-intensive project, the impact will be particularly felt on the project's water and energy supply and, consequently, on its operating costs.

The increased temperatures would exacerbate water scarcity, hampering extraction operations and putting the companies in direct conflict with communities over water resources. This would even complicate site rehabilitation.

An increase in rainfall would result in an increase in the volumes of water to be managed and treated and a potential decrease in the capacity of settling ponds to accumulate wastewater from the site. There is also talk of a possible destabilisation or weakening of the slopes at the operation sites. Flooding would exacerbate the risk of settling pond failure and the release of contaminated wastewater to surrounding areas. This would affect the health of the communities. The proponent's environmental liability would increase and would result in increased costs related to the management and treatment of increased volumes of water and sanitation costs.

These climatic events would affect the efficiency of infrastructure and equipment and could interrupt production operations. They would also require additional controls to improve water-treatment capacity.

In the region, under normal operating conditions, this heavy oil project is considered the key driver of local (and even national) economic development. However, changing climatic conditions pose a real threat to its viability and profitability.

Fig 10.4 Process in gold rush mining.

In gold-mining activities

The gold-mining sector is not immune to the risks associated with climate change. Heavy rainfall causing intense erosion can affect the stability of slopes at mining sites. Increased temperatures and precipitation[26] may damage mining infrastructure and equipment and affect transportation services. These transportation services provide goods and services, transport personnel, and move ore to processing points or facilities and to ports for export. More frequent and intense natural disasters[27] can damage facilities, delay operations, and even landlocked mine sites. They also pose immediate health and safety risks to workers, particularly gold miners, and local communities by exacerbating food and water shortages and increasing the prevalence of tropical diseases.

26 CO2 emission factors considered, according to IPCC: 820g CO2/kWh for the coal-fired plant, and 266 g CO2/kWh for the diesel plant. Tropical Storm Eliakim, the 5th of the hurricane season, March 16, 2018 (after Ava in January 2018 and flooding in the north in February 2018) at the level of Cape Masoala, remained for almost 24 hours in the district of Maroantsetra before going out to sea on 18 March in the district of Vatomamdry.

27 Madagascar first issued green alerts for the Madagascan districts of Diana, Sava and Sofia on 4 December 2019, based on a high probability of Belna impacting north-eastern Madagascar.

On the other hand, in the event of drought, another manifestation of climate change, increased water stress could significantly affect gold-mining operations insofar as gold-mining methods in particular require disproportionally large quantities of water. In such circumstances, access to an adequate water supply would become uncertain and difficult. The subsequent costs of water management and treatment before and after operations will increase inexorably.

Difficulties in financing fossil-fuel exploitation projects: The case of Sakoa mining coal

A global ecological aversion to mining coal

International experts agree that, if the world is to be protected from dangerous climate change and other negative impacts associated with mining coal (for example, local air pollution), global mining coal consumption peaked and then declined by 2020. More importantly, mining coal is expected to disappear permanently from the global energy system by 2050 and even earlier (WWF, 2015). The reason the world needs to move away from a dependence on mining coal has recently been highlighted by the Intergovernmental Panel on Climate Change (IPCC): if humanity is to have a chance of not exceeding the 1.5°C warming limit by the end of this century, compared to the pre-industrial period, it must not exceed the IPCC's estimated cumulative carbon emission credit of 655-815 Gt CO_2 between now and 2050 (Allen, Babiker, Chen & de Coninck, 2018).

More than two-thirds of the cumulative global greenhouse gas emissions (about 50 Gt per year) are attributable to CO_2 emissions in the energy sector. With approximately 14 Gt CO_2 emissions, mining coal is the largest CO_2 emitter among all fossil fuels (32 Gt). Thus, the IEA[28] concludes that more than two-thirds of the economically available fossil-fuel reserves (80% for mining coal due to its high carbon intensity) must be "kept underground."

According to IRENA[29] (June 2020), renewable energy sources are today much more competitive than fossil fuels for electricity production; the transition to renewable energy for electricity production is clearly established. Financial investments

28 International Energy Agency

29 International Renewable Energy Agency

are increasingly turning away from fossil fuels (oil and mining coal) in view of the challenges of sustainable development, climate change, and for economic reasons. The oil crisis linked to the Covid-19 pandemic is a time to consider this shift more drastically. An exit from fossil-fuel investments, therefore, makes a great deal of sense from an economic point of view (Washington Post, May 2020).

A global financial disinterest in mining coal

In June 2015, the newspaper *La Tribune* reported, citing a report published in March 2015 by the Coalswarm network of researchers and the American NGO Sierra Club, that between 2003 and 2014, coal-plant closures worldwide were 22% higher than construction. More than 200 institutions, representing the equivalent of 50 billion euros in assets, have decided to stop their fossil-fuel commitments. This is the case in the United Kingdom of the World Council of Churches and the British Medical Association, as well as of Stanford University and Glasgow University.

At the climate summit in New York in September 2014, the Rockefeller Brothers Foundation caused a sensation by announcing the withdrawal of its philanthropic funds. In France, where banks have increased their investments in the fossil-fuel sector by more than 200% between 2005 and 2013, the three banks involved (BNP Paribas, Société Générale and Crédit Agricole) have committed to no longer finance mining projects in the Galilee Basin on the east coast of Australia, which alone would emit almost as much CO_2 per year as Germany. In Norway, the sovereign fund (870 billion euros, or 1.5% of the world's capitalisation) has begun its transformation (Pialot, 2015). Fuelled by oil money, it has long excluded certain sectors (arms industry, tobacco, human rights violations, etc) and has begun to sell certain coal-related assets. In May 2020, by tightening its criteria for excluding coal, the Norwegian fund, which is very committed to the fight against global warming, ranked the major mining companies on the same level as the electricity and oil companies with the highest emissions.

La Tribune also reported that, at the same time, for the first time in the century, Chinese coal production decreased by 2.1% in 2014. Imports fell by 42% in the first three months of the year, in a country that accounts for 50% of global consumption. Moreover, the slowdown in economic growth is far from being the only cause of this turnaround, which is primarily linked to the decarbonisation of the economy. Thus, China's CO_2 emissions per unit of GDP fell by 29% between 2005 and 2013, and by nearly 5% again in 2014 when growth was at 7.4%. The authorities indeed addressed the dramatic consequences of coal combustion on the health of the population, which would reduce life expectancy by five and a half years in northern China, and by more than three years in India.

The subject is beginning to cause concern in financial circles, which fear a more structural rather than cyclical evolution: Goldman Sachs has publicly estimated that coal is an energy in decline. In this context, the risk of seeing certain power plants turn into unusable or "failed" assets is increasingly mentioned. A study by Carbon Tracker estimates the total power of the Chinese assets by 2020 will be 437GW, i.e., 40% of the installed capacity at that date, of which 127GW is already built (and 47GW in 2014 alone). In financial terms, the researchers estimate that the planned investments could be "stranded" by 2035 at $100 billion. The financial players themselves are looking into the subject. The Bank of England has included it in its programme to assess for its own account these risks related to the energy transition. Insurers (whose economic model is directly threatened by the consequences of climate change) could also start to need to be begged to support new projects.

The uncertain and questionable future of the Sakoa coal-mining project

The possible exploitation of the mining coal deposit in the south-west of the country would contradict Madagascar's commitments to counter climate change and could strongly undermine the credibility of the country's dependence on climate financing for its climate-change adaptation efforts. Paradoxically, despite its stated willingness to move towards an energy transition based on renewable energies, the opportunity to exploit Madagascar's coal deposits for power generation is regularly mentioned in the speeches of successive political regimes. Thus, a project for the construction of a 100 MW coal-fired power plant by Asian and South African investors is listed by the Global Coal Public Finance Tracker.The mining coal would come from the exploitation of the Sakoa deposit in the south-west of Madagascar.

The project of exploitation of the Sakoa (Sakoa, 2015) mining coal deposit is the subject of a partnership between Madagascar Consolidated Mining SA (MCM) and PAM Sakoa SA (PAMS); the two companies have joined forces in order to optimise the mining coal resources of the area and optimise investments in plant and infrastructure. The Chinese state-owned company CCTEG Beijing Huayu Engineering Co. Ltd (BHED) has been engaged for a feasibility study of a bankable project including (i) underground mining operations (potential of 82 million tons for a projected production of 5 million tons per year for 17 years); (ii) open-pit mining operations (potential of 26 million tons for a projected production of 3 million tons per year for 19 years); (iii) mining coal handling and processing operations (washing efficiency of 79.5%); as well as (iv) the construction of a railway (160 km from the operating site to the port) and a port (Soalara port capable of handling 70 000 tons of cargo).

Thus, the consumption for the production of electricity of all the mining coal produced by the Sakoa deposit in Madagascar, estimated at 879 GWh, would be responsible for the emission of about 0.72 MTeq $CO_{2,}$ i.e., nearly 47% of the emission reduction efforts in the energy sector (excluding biomass) in Madagascar in 2030 (IPCC, 2014). In other words, the emission reduction claims in 2030 compared to the BAU scenario in the energy sector (excluding biomass), and to which Madagascar is committed, would have to be halved if the production of mining coal was actually done.

At a time when countries are being asked to make more efforts following the Paris Climate Agreements, one may wonder what this would mean in terms of impacts for Madagascar. In particular, as a country heavily impacted by climate change, Madagascar needs financial support to implement its adaptation strategy and to develop access to energy (84% of the population did not have access to electricity in 2015); its willingness to participate in global reduction efforts and to meet its commitments can be weighed against this possible financial support. The global climate challenges and its consequences in terms of growing economic and financial disinterest in investments in the coal-mining sector could make it impossible to implement the project to exploit the Sakoa mining deposit.

In 2015, the Sakoa mining project was planned to be developed within the framework of financing from Chinese banks. The construction of infrastructure and plants was planned for 2016 and the first production of mining coal in 2020, with the target market being power plants and cement manufacturing plants in India, South East Asia, South Africa and Madagascar. PAM Sakoa has obtained a conversion of its research permit into an operating permit between 2009 and 2013, but is still at the pre-feasibility stage; MCM has obtained the conversion of its five research permits into operating permits, three of which already have their environmental permit. Thus, in light of the global evolution of mining financial investments affected by climate change, it is reasonable to question whether this project will be able to find the necessary financing for its development.

Even if the example taken here focuses on mining coal, this global disinterest in fossil energy investments could affect oil exploration and exploitation in Madagascar, regardless of the economic situation related to the global health situation. Therefore, it appears necessary for Madagascar to think strategically and be visionary about the relevance and feasibility of promoting its hydrocarbon deposits in a development framework that must necessarily embrace low carbon emissions.

Conclusion and recommendations

By the end of this study, it was clear that Madagascar must take a radical turn towards an improvement in its policies in terms of the exploitation of mining resources, environmental protection, the fight against climate change, and energy transition. These policies should be combined in an integrated manner to move towards a resilient and beneficial development for both local populations and the national economy.

Madagascar is committed to the transition towards renewable energy, which is part of its efforts to reduce greenhouse gas emissions, thus contributing to preserving its status as a carbon sink country in 2030. Combined with actions to increase its absorption capacities, these emission-reduction efforts could enable Madagascar to move from the status of a carbon emitter to that of carbon sink in 2030. Moreover, even if the contribution of the country to global warming is marginal, the island is significantly affected by climate change. In addition to its economic fragility, its geographical location and its heavy dependence on natural-resource-based commodities – for its subsistence and national income – make it particularly vulnerable to climate change.

The extractive industry sector contributes globally to climate change mitigation efforts through the production of key raw materials. However, the exploitation of raw material deposits can also contribute to climate change. The impact of the extractive industry on climate change requires sustained attention from government and mining companies. In addition, the climate change adaptation measures of the extractive industry sector need to be strengthened.

Two sets of recommendations are made for the extractive industry in Madagascar: the choice of a low-carbon development path and the adoption of a proactive approach to climate-change adaptation.

For a low-carbon development path

Public authorities should:

- Strategically and in a visionary way analyse the relevance and feasibility of promoting Madagascar's fossil-energy deposits (mining coal, unconventional oil, and conventional oil) in a development framework that must necessarily be low carbon and contribute to global efforts to fight climate change.
- Define the national mining and oil policy and strategy, and review/improve and adopt legislation in a participatory and inclusive manner.
- Conduct a strategic environmental assessment of the integrated national and regional economic development plans of Madagascar, including the development of extractive industry projects, to assess whether the benefits of the extractive industry project(s) outweigh the risks, prior to any decision making for their development.
- Integrate measures to reduce carbon emissions in investments in the extractive sector, as part of the development of integrated national and regional economic development plans in Madagascar, including the development of extractive projects.
- Encourage the reduction of carbon emissions in extractive industry investments, namely, by establishing a synergy between power-generation projects that valorise renewable energies and extractive industry projects. The ultimate post-2030 goal would be to shift power generation for extractive industry needs from fossil fuels to fully renewable sources.
- In the context of cross-sectoral collaboration, improve the governance of Madagascar's artisanal mining sector by strengthening the government's capacity to enforce related national legislation (including mining and environmental laws) and monitor compliance by artisanal miners, while accelerating the formalisation and legalisation of artisanal activities.

- Strengthen the capacity and effectiveness of monitoring and regulatory bodies, and consolidate frameworks for assessing, managing and regulating the impacts of extractive industries (including climate impacts).

On the other hand, mining operators and mining project promoters should align themselves with the energy transition in view of the high energy consumption of the sector. They can achieve this by reducing, as much as possible, the consumption of fossil energy in activities, whether for energy production or the transportation of materials, products and personnel. They should also implement strict measures to preserve people's health and quality of life.

For a proactive approach to climate change adaptation

Public authorities need to raise awareness and assist smallholders and gold miners to develop emergency plans and procedures to prepare for the intensification of natural and climate disasters, as well as pandemics, and to identify risk-management options and adaptation measures to be considered. They must also collaborate with all stakeholders to ensure that communities have access to information related to extractive industries and climate.

As for operators and promoters of mining projects, they should assess climate risks and opportunities prior to their investments, and review their exploration and production strategies. They can achieve this by developing approaches to reduce the vulnerability of their activities at all phases, enabling them to adapt to climate change while reducing their carbon footprint. It is also recommended that they integrate the principles of social solidarity, effective local content, intergenerational equity, and polluter pays into any project development and project management plan.

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11

Climate Change Mitigation and Adaptive Capacity in the Zimbabwean Mining Space

Nqobizitha Dube

Abstract

This paper discusses the climate mitigation and adaptation situation in Zimbabwe's mining industry. Specifically, the paper explores levels of climate change knowledge, attitudes, and perceptions of senior managers in the mining industry. It also estimates the carbon footprint of major mineral producers in Zimbabwe and documents the possible carbon mitigation options available to Zimbabwean mining entities in the short and long term. From an adaptation perspective, the paper considers climate risks associated with the Zimbabwean mining sector and possible adaptation options in both the short and long term. This study followed a qualitative, exploratory, descriptive design focused on specific case studies in Zimbabwe's mining sector. Results showed a fair knowledge of climate change issues in the sector. However, evidence from primary data showed higher concern for current than future situations. Major climate risks highlighted are floods, violent storms, water scarcity and heatwaves, while the adaptation initiatives include water harvesting, dust suppression, water recycling, use of heat resistant equipment, and building climate change management capacity of mine employees. The major mitigation options were carbon sequestration, reducing the use of fossil fuels, and emissions accounting and guidelines.

Introduction

Tietenberg and Lewis (2019) streamlined climate change management into mitigation, adaptation and weather engineering. Of the three, climate adaptation[1] and mitigation[2] have taken center stage in climate change debates, particularly in the developing world (Abd El-Mawla, Badawy and Arafat, 2019; Schneider, 2019). Within the climate change management debates, adaptation perspectives tend to be compensatory while those on mitigation are largely punitive (Preston et al., 2014).

Downscaling climate change management perspectives to national spaces, Zimbabwe has largely focused on adaptation, particularly in regards to household livelihoods (Chanza et al., 2019; Chagumaira et al., 2016; Brown, 2012), agriculture (Mutandwa, Hanyani-Mlambo and Manzvera, 2019; Muzari, Nyamushamba and Soropa, 2013), and disaster risk management (DRM) (Pritchard et al., 2020; Ncube and Tawodzera, 2019 and Unganai, 1996). Outside of livelihoods, agriculture and DRM, climate change studies in Zimbabwe have also considered water utilisation efficiency (Govere, Nyamangara and Nyakatawa, 2019), carbon conservative supply chains (Lee, 2012), and movement towards a sustainable green economy in Zimbabwe (Murombo, 2020; Kupika, Gandiwa and Nhamo, 2019).

Unlike the case of adaptation, where research has managed to tackle grassroots issues, mitigation studies in Zimbabwe remain largely national and not specific to particular sectors of the economy (Murombo, 2020; Muza & Magadi, 2014). The result is skewed climate change management initiatives that have clear adaptation but murky mitigation solutions despite a national climate policy that considers numerous socio-economic sectors — Agriculture, Health; Infrastructure; Human Settlement; Energy; Industrial processes; Waste; Land-use, land-use-change; Forestry and Biodiversity—(Zimbabwe Climate Policy, 2016). Such bias towards adaptation and the failure to have climate change management information for specific socio-economic sectors of Zimbabwe results in information crevices' that weaken environmental sustainability in various sectors.

1 Refers to the ability of individual mines and the sector as a whole to address, plan for, and/or adapt to these conditions.

2 Climate change mitigation refers to the pursuit of those activities and processes that reduce the emission of GHGs in human systems

This paper contributes to remedy this situation by explaining the climate mitigation and adaptation situation in Zimbabwe's mining industry. This contribution is made using a case study of major extractive firms in Zimbabwe's mining industry. Specifically, the paper explores the climate change knowledge levels, attitudes and perceptions of senior managers in the mining industry. From an adaptation perspective, the paper considers the climate risks associated with the Zimbabwean mining sector and the possible adaptation options. Regarding mitigation, carbon footprint estimates of major mineral producers in Zimbabwe are made before documenting the possible mitigation options available to Zimbabwean mining entities. The paper then explains the methods used to realise the above-mentioned goal and sub-objectives of the study, followed by brief descriptions of the major mining firms selected for the study. The study findings and conclusions are rooted in empirical research as demonstrated in the paper..

The text

This study followed a qualitative, exploratory, descriptive design focused on specific case studies in Zimbabwe's mining sector. The sector was stratified in accordance with minerals produced—precious metals and stones, and manufacturing input minerals—and the overall output of the mine from a revenue perspective. Key informants (KIs) within selected mines were purposely chosen based on their position and the levels of knowledge they possessed. These individuals included Safety Health and Environment (SHE) officers and mine engineers. Primary data was collected using key informant interviews (KIIs) while secondary data was sought from internal organisational documents of the case study mining firms. Seven KIIs were conducted in six mining firms involved in the extraction of various minerals as shown in Table 11.1.

Table 11.1. Key informants and their organisational affiliations. *(**Source:** Nqobizitha Dube).*

Organisation	KI Position in the mine	Major mineral mined
Bindura Nickel Corporation (BNC)	Mine engineer	Nickel
Hwange Colliery Company	SHE officer	Coal
How Mine	SHE officer	Gold
	Mine engineer	
Mimosa Platinum	SHE officer	Platinum
Pretoria Portland Cement (PPC)	SHE officer	Limestone
Zimbabwe Consolidated Diamond Company (ZCDC)	SHE officer	Diamonds

In analysing the adaptive capacity of the mining industry, this study used the current and future vulnerability framework proposed by Pearce et al. (2011). When using this framework, analysis begins by identifying current climate vulnerabilities faced by the sector, which directly feeds into an assessment of vulnerability to future climate change.

The life cycle method is used to estimate the carbon footprint in the case study mines. It is then used to infer an average industrial carbon footprint. A number of variations of the life cycle method have been used to calculate carbon footprints in literature (Valente, Iribarren & Dufour, 2019; Ghani, Silalertruksa & Gheewala, 2019; Scipioni et al., 2012; uek, Klemeš & Kravanja, 2012; Frischknecht & Jungbluth, 2004). In this case, a variation of the life cycle hypothesis explained by Aziz and Kecojevic (2008) has been employed. This method has five steps:

Step 1 identifies and calculates the total energy (TE) consumed by the mining firm of interest, followed by identification of the percentage of fuel type *(%FT*) which makes up *TE,* as shown in Equation 1. Identification of fuel type gives the fuel mix of the mining processes in the firm of interest, given that emissions will vary in accordance to the fuel used by the mine.

$$TE = \sum_{FT=1}^{\infty} FT \quad (1)$$

Step 2 calculates the energy consumed per fuel type (*EFT*) by taking the *TE* identified in Step 1 and multiplying it by each fuel percentage proportions to give total energy consumed in accordance to the fuel type as shown in Equation 2.

$$EFT = TE \text{ x } \%FT \ (2)$$

Step 3 identifies the CO_2 emission coefficients (EC_{FT}) per fuel type which are usually reported in Kgs of CO_2. The combustion of fuel can be estimated with a high degree of accuracy regardless of how the fuel is used, given secondary data on fuel emissions (Shan et al., 2016; Weller et al., 2019). In cases where electricity from the grid is used, only thermal power from coal-fired generation plants will be considered. In this regard, the *EC* for electricity will be estimated using the average *EC* for Bituminous coal in proportion to the national generation capacity (*NGC*) of clean energy (hydro, solar, wind, etc.,) and thermal coal-fired power (*TP*). Therefore, electric energy used at the specific mine that will be used to calculate the CO_2 is given by the total electricity used (*TEU*) at the mine multiplied by *TP* percentage of *NGC*.

Step 4 calculates the CO_2 emitted per fuel type by multiplying the energy consumed by fuel type by the emissions coefficient for the respective fuel type as shown in Equation 3.

$$\text{Total } CO_2 \text{ emitted} = EFT \text{ x } EC_{FT} \ (3)$$

Step 5 aggregates CO_2 emissions by all fuel types to give the overall CO_2 footprint for the mining firm of interest. The overall CO_2 footprint is then divided by the annual mining output in kgs to give the carbon footprint of a kg of mineral produced. This value is then used to estimate the CO_2 emission of national production of a particular mineral.

Case study mines

Hwange Colliery Company

Hwange Colliery Company was founded in 1899. It is involved in the mining, processing and marketing of coal in Zimbabwe. The major Hwange colliery mine is located and headquartered in Hwange town in Matabeleland North Province (see Fig 11.1).

How Mine

How Mine has been in operation since 1942. It extracts and processes gold ore. How Mine is situated in the Bulawayo greenstone belt (Fig. 11.1). It comprises a single underground operation, where ore is processed at a central processing facility.

Zimbabwe Mining and Smelting Company (ZIMASCO)

The Zimbabwe Mining and Smelting Company (ZIMASCO) ferrochrome smelters is located in the City of Kwekwe in the Midlands Province of Zimbabwe. ZIMASCO has mined ferrochrome on the Great Dyke since the 1900s (Fig. 11.1).

Pretoria Portland Cement

Pretoria Portland Cement (PPC), Zimbabwe is the country’s largest and oldest (125 years) cement manufacturer. PPC mines and processes limestone into cement. There are three PPC plants in Zimbabwe, Colleen Bawn, Bulawayo and Harare (Fig. 11.1).

Mimosa Mine

Mimosa platinum mine is located on the Great Dyke in Zimbabwe. Mimosa is the oldest platinum mine in Zimbabwe, having began mining operations in 1926. Trial mining started in 1966 with the sinking of two vertical shafts. The mine is accessed through the Wedza and Mtshingwe shafts (Fig. 11.1).

Bindura Nickel Corporation (BNC)

Bindura Nickel Corporation (BNC) operates mines and a smelter complex in Bindura, Zimbabwe (Fig.11.1). BNC is operated and owned by Mwana Africa PLC and is engaged in the mining and extraction of nickel, and production of nickel by-products (copper and cobalt).

Fig 11.1. Location of study mines. *(**Source:** Nqobizitha Dube.)*

Findings

This section discusses the climate mitigation and adaptation situation in the case study mining firms. It discusses climate change knowledge levels, attitudes and perceptions, and adaptation to climate change. Also, carbon footprint estimates of the case study mines made before documenting the possible mitigation options available to Zimbabwean mining entities are discussed.

Climate change knowledge levels, attitudes and perceptions in the mining sector

Examining the knowledge levels and perceptions around climate change among various stakeholder groups allows policy makers and related stakeholders to determine effective communication and education channels. This could ultimately reveal new and potentially beneficial insights into behavioural change. Literature on climate change knowledge perceptions uses indicators such as belief that the climate is changing, knowledge of the causes of climate change, concern that climate is changing, impacts of the changes, and possible solutions (Lee, Tung & Lin, 2019; Selm et al., 2019; Shi et al., 2016; Liu, Smith and Safi, 2014). In line with the dimensions found in literature, KIs interviewed in the case study mining companies all agreed that the general climate in Zimbabwe was changing. The major changes cited were increased frequency of heat waves, unreliable rainfall, shortening of the rainfall seasons, and recurrent droughts.

Regarding the causes of climate change, all key informants cited global warming due to rising global GHG emissions in general and CO_2 in particular. The only other GHG mentioned in primary data collected from the KIs was methane (CH_4) — mentioned by one KI — while the other common GHGs — Nitrous Oxide (N_2O), water vapour (H_2O) and Ozone ($O_{3)}$— were largely missing. In some cases, Sulphur dioxide (SO_2) was cited as a direct member of the GHG family while in actual effect it is an indirect GHG. Also, the more esoteric aspects of the causes of climate change such as radiative forcing —not discussed entirely— and rising sea levels —discussed by one KI— seemed elusive.

Regarding concerns over climate change, KIs in all case study mining companies noted that climate change was a major contemporary global issue —see interview quotes Q1 and 2— that was also visible in the mining space. When asked to numerically give the importance of climate change issues in the mining business on a scale of 1 to 10 —1 being least important and 10 being most important—, KIs in gold gave an average score of 5.5, platinum (7), coal (2), chrome (9), limestone (6) and Nickel (5).

Q1. "Climate change is an important issue. We may be alive today, but we still have more generations to come. As such, I strongly believe climate change is an issue that needs to be addressed. people must work together to combat climate change." (Mimosa KI, 2020).

Q2. "Climate change is an important global issue however it is not being given the much-needed attention." (Hwange Colliery KI, 2020).

Aspects of climate change management were also fairly well known as respondents discussed issues related to mitigation and adaptation to climate change (see Q3 and Q4). Despite the commendable knowledge of esoteric aspects of climate change management, Q4 highlights an over emphasis on issues related to mitigation rather than adaptation. This dimension was echoed by other KIs (those not representing Mimosa) who explained that their discussion and understanding of climate change in the mining sector was predominantly focused on emission of GHGs by mines in line with perspectives in literature (Pearce et al., 2011).

Q3. "In the case of climate change mitigation, we asked the question, what can we do solve this problem or stop the problem while in adaptation we asked what can be done so that we can live or coexist with this problem." (ZIMASCO KI, 2020).

Q4. "Regarding climate change mitigation measures, we have to limit GHGs emission, practice reforestation. We also need to introduce what I refer to as green culture or use environmentally friendly products. Mitigation strategies include setting targets to reduce emissions, use of solar energy and government control of emissions by individuals and industries, protection of wetlands." (Mimosa KI, 2020).

Regarding future expectations on climate change, KIs in the gold mining space expected the situation to get worse in the near future with strong fears of frequent floods, lack of timber, and water scarcity. KIs in the platinum and limestone sectors also expected the situation to worsen further. In addition, they noted the importance of political will, both at national and global levels, if climate change and its impacts are to be addressed. Furthermore, KIs in the platinum sector lamented the absence of green technologies that could ease the emission of GHGs while KIs in the coal sector expressed concerns over inadequate attention towards addressing climate change.

Primary data shows a fair level of knowledge on climate change issues, particularly on its presence and causes. Data also shows that mining sector stakeholders generally expect the situation to get worse. In some cases, however, stakeholders seem not to have climate change high on the business agenda, as indicated by low scores on the importance of climate change in their businesses. This is a case of profit versus environmental sustainability, which Goldstein et al. (2019: 18) explained as the "tragedy of the horizon" highlighting the mismatch between short-term business decisions and the long-term effects on climate change. Azapagic (2004) further explained that the main challenge for the mining sector is to clearly demonstrate that it contributes to the welfare and well-being of the current generation, without compromising the potential of future generations for a better quality of life. In this case, evidence from primary data suggests that despite high notable knowledge and acceptations that climate change is a contemporary issue, needs of the current generation still largely supersede those of future generations in the mining sector.

Climate risks in the Zimbabwean mining sector

The United Nation Intergovernmental Panel for Climate Change (IPCC) is the leading organisation in developing methodologies to address the challenges of climate change. Humanity is inherently vulnerable to climate change though the levels of vulnerability vary from location to location (Malakar & Mishra, 2017). Significant changes to the concept of vulnerability are noted between the fourth and fifth IPCC Assessment Reports (ARs) (IPCC, 2007, 2015). In AR4, vulnerability factors include exposure, sensitivity, and adaptive capacity, while AR5 emphasizes on the concept of climate change risk. In this study, aspects of climate change risk within the case study mines are also considered in order to shed light on issues that are not normally discussed in sectors synonymous with emissions, such as mining. Goldstein et al. (2019) noted climate change as one of the major contemporary business risks that companies have failed to adequately characterise in their reporting. In that regard, primary data respondents cited a number of climate risks that may be divided into primary exposure, availability of ecosystem goods and services, mine sensitivity — from a human and non-human dimension— and profitability.

Exposure in climate change parlance refers to the direct contact that human and natural systems have with the weather elements (IPCC, 2015). Elements of exposure that were cited in the amalgam of climate risk included the exposure to flooding, high temperatures, violent storms, and water scarcity due to drought. KIs explained that flash floods and violent storms presented operational risks as they often negatively compromised operations given that flood conditions often disallowed normal mining activities on site (see Q5). Heatwaves were also found to have become regular in the hot seasons, resulting in labour productivity challenges as the heat took a toll on individual workers and at times resulted in spontaneous burning (see Q6). KIs from the case study mines also conceded that droughts had become recurrent resulting in lowering of the water table and water scarcity for regular mining operations.

> *Q5. "We have the issue of sporadic rainfall, climate change brings sporadic rainfall, these affect mining, in the sense that most of the mines in Zimbabwe are not fully equipped to prevent flooding, when these sporadic rains come, thus affecting work flow and operations. Sometimes mines collapse or are flooded." (Mimosa KI, 2020).*

Q6. "Hwange is predominantly an open cast mine and high temperatures caused by heatwaves often result in spontaneous burning of coal which is dangerous. Change in atmospheric temperatures also affect stockpiling and bunker levels." (Hwange colliery KI, 2020).

Primary exposure to climate change inevitably impacts the availability of ecosystem goods and services. For instance, KIs from How Mine explained that recurrent droughts had negatively impacted on the availability of timber, which had negatively compromised mine operations (see Q7 and Q8).

Q7. "Water is a very important resource for all our day-to-day mining operations from extraction to processing. It is used as a lubricant and coolant during drilling, for dust suppression, washing down, and as a transfer medium during the ore processing stage. Also, the availability of timber is negatively affected by drought." (How Mine KI, 2020).

Q8. "Climate change also affects mines in the sense that mines use groundwater for operations, if climate is changing adversely, it means we are going to experience water scarcity which we need for mineral extraction, processing etc. Looking at the future, water table will drop and this will affect the operations." (PPC KI, 2020).

Climate change sensitivity in general refers to the degree to which a system will change due to change in climate (IPCC, 2015). In this case, the systems at the case study mines that could be at risk of climate change are human and machine systems. Regarding human systems, KIs explained that the employees were at risk when they worked under conditions of extreme heat and floods. The resultant effects of exposure shown in Q6 —sporadic burning— may also result in the loss and damage of capital equipment that is crucial to mine operations. According to KIs from BNC, for ventilation, most mines adopt a negative pressure system with exhaust fans that suck air out of the mine. This generates a negative pressure gradient between the underground and the surface conditions. In hot conditions, however, the efficiency of this method is compromised. Mines therefore adjust their ventilation system in hot conditions by using booster fans and increasing the power of the exhaust fans. The human and non-human dimensions of sensitivity ultimately result in low productivity and low profits for the mines as highlighted in Q9.

> *Q9. "The other issue is that climate change brings adverse health effects to the workforce especially considering high temperatures, heatwaves affecting the well-being of employees hence reducing productivity." (BNC KI, 2020).*

Primary data collected from the case study mines shows that like all other businesses, mines suffer from notable climate risks which inevitably affect their viability. Similarly, Pearce et al. (2011) noted that in Canada, transportation routes and mining infrastructure are susceptible to structural weakening and failure due to increased frequency and severity of extreme weather events and climate variability. Depending on the nature and location of a mine, containment facilities, buildings, energy sources, and mine site drainage may be affected by permafrost thaw, rising average temperatures, stronger winds, changing water levels and ice composition, and greater intensity and frequency of precipitation (Pearce et al., 2011).

Therefore, when considering climate change risk, the climate change issues cease to be a tragedy of the horizon but rather an immediate problem with immediate effects on viability. Such risk is not only of importance to the immediate mining stakeholders but to Zimbabwe as a whole given its economic dependence on minerals (Muchaendepi et al., 2019; Murombo, 2013).

Adaptation options

Climate change risk inevitably requires climate change management techniques which, according to Tietenberg and Lewis (2019), centre on adaptation, mitigation and weather engineering. These management dimensions received the support of decision-makers from 194 countries during the December 2011 United Nations Framework Convention on Climate Change (UNFCCC) seventeenth Conference of the Parties (COP17) in Durban, South Africa. The Convention made progress with plans to finance global mitigation and adaptation efforts through the Green Climate Fund (GCF) to the tune of USD 100 billion sourced from developed nations.

In the same vein, this section focuses on adaptation to climate risk and uses the primary data perspectives of the case study mines to explain climate change adaptation options in the Zimbabwean mining space. The mines, like other earthly systems, are inherently vulnerable to climate change and in this case, vulnerability is a function of exposure-sensitivity to climatic risks and the adaptive capacity to deal with those risks. Adaptive capacity refers to the ability of individual mines and the sector as a whole to address, plan for, and/or adapt to these conditions (Pearce et al., 2011).

Although no single established typology of adaptation actions exists, Jones, Hole and Zavaleta (2012) categorised adaptation into 'soft,' 'hard' and ecosystem-based approaches. Soft approaches generally focus on information, policy, capacity building and institutional function. Hard approaches use specific technologies and actions involving capital goods to reduce potential climate change impacts. Ecosystem-based approaches to adaptation (EbA) harness the capacity of nature to buffer human communities against the adverse impacts of climate change (Jones, Hole & Zavaleta, 2012).

Respondents from the case study mines highlighted a number of adaptation options that they felt were best suited to the Zimbabwean situation. KIs from How Mine suggested the construction of more dams to harvest water, which was increasingly becoming scarce. How Mine respondents also suggested the recycling of water — using underground reservoirs and tailing ponds— and an increased focus on development of ground water resources. KIs from Hwange Colliery suggested the procurement of more standby pumps to pump water, stockpiling of crushed product, quick movement of coal on stockpile, and deliberate factoring-in of wet season delays in mining activities. KIs from Mimosa argued for technologies and equipment that are resistant to weather extremes, particularly heat. Mimosa KIs and those from PPC advocated the training of internal employees in issues of climate change management.

The adaptation options given in the primary data predominantly focus on hard options and slightly on soft options that relate to the training of employees and the re-organisation of work structures and schedules. Missing in the adaptation options are EbAs which were not mentioned by any of the KIs. Jones, Hole and Zavaleta (2012) explain that the potential scope of EbA to help reduce vulnerability to a range of climate change impacts is broad because ecosystems deliver services that can help meet adaptation needs across multiple human development sectors. In this regard, this dimension of adaptation has to be advocated for in mining and other Zimbabwean industries. The responses from the KIs also present the overall current and future adaptive capacity of the mining industry in Zimbabwe as summarised in Table 11.2 in line with (Pearce et al., 2011).

Table 11.2. Adaptive capacity of mining entities in Zimbabwe. *(**Source:** Nqobizitha Dube.)*

Current Vulnerability	Future Vulnerability
Exposure-sensitivities: a) Floods: Make work dangerous and mining sites inaccessible. b) Violent storms: Make work dangerous and mining sites inaccessible. c) Droughts: Reduce amount of water available for mining activities and processing, and limit availability of critical ecosystem goods and services such as timber. d) Heat waves: damage equipment and negatively impact labour productivity.	a) Estimated future exposure-sensitivities: b) Increased flash floods. c) Increased droughts, water scarcity and lack of strategic ecosystem and services such as timber. d) Increased heatwaves and labour productivity declines. e) Declining output and profits.
Adaptation options identified: 1. Building dams and other water harvesting technologies. 2. Harvesting ground water. 3. Building the capacity of employees on climate change management. 4. Prioritising climate proof equipment and technologies. 5. Aligning the work schedule to changing climate.	Viability of adaptation options in the future: 1. Despite the bias towards hard adaptation options, the implementation of identified adaptation options could improve the adaptive capacity of mines. However, there is need for willingness to change the business-as-usual approach at the strategic levels of mining businesses. There is also need to include more soft adaptation options and EbAs.

Mitigation and carbon footprint

Climate change management also encompasses aspects of climate change mitigation which previous discussions have shown to be more synonymous with the mining industry. Climate change mitigation refers to the pursuit of activities and processes that reduce the emission of GHGs in human systems (IPCC, 2015). In this study, all KIs from the case study mines admitted that their business activities contributed to GHG emissions and likely to climate change—see examples in Q10-12.

> *Q10. "Mines should factor in climate change as they do business because to some extent, mines contribute to climate change. At How Mine we used to have old fridges which were producing chloro fluorocarbons (CFCs) which contribute to climate change." (How mine KI, 2020).*

> *Q11. "Mines definitely need to consider climate change as they go about their business because mines emit a lot of GHGs. For example, when coal is burnt it produces Sulphur dioxide which contributes to climate change. Besides that, there are Conventions that were ratified by Zimbabwe which require industries to address climate change." (Hwange Colliery KI, 2020).*

> *Q12. "Mines should consider climate in their business because, they really affect the climate and contribute to climate change. We have processing plants which emit GHGs into the atmosphere, we have machinery that release diesel particulate matter into the atmosphere. Mines are supposed to be environmental-friendly and reduce emissions, that is, strongly taking action address climate change." (PPC KI, 2020).*

From the quotes above, the respondents view mines as major producers of GHGs and further that the mines should take responsibility for this negative action from a climate change management perspective. In an attempt to guide the 'taking of responsibility,' this study sought to estimate the carbon footprint of the case study mines and use it to estimate overall carbon emissions by the Zimbabwean mining sector. According to the respondents, the major mining activities that produce GHG emissions include drilling and blasting, hauling, crushing, milling, metallurgical extraction and effluent disposal. Table 11.4 summarises the stages in the estimation of the carbon footprints of the different minerals in accordance with primary data collected from the case study mines.

In line with Aziz and Kecojevic (2008), this study used the United States of America energy information administration reports to estimate the emissions coefficients of the common fuels used in the case study mines (EIA, 2020). In the case of electricity, GET-Invest (2020) notes that Zimbabwe's electrical power comes from various sources which include coal, water, sugar cane bagasse, and wood —see Table 11.3.

Table 11.3. Electricity generation capacity in Zimbabwe. (**Source:** *Adapted from GET-Invest (2020).)*

	Power Station	Owner	Installed Capacity (MW)	Total (MW) (proportion of national)
Hydro	Kariba Dam Hydroelectric Power Station	ZPC	750	750.75 (36.9%)
	Rusitu Hydro	Rusitu Power Corporation	0.75	
Coal	Hwange Thermal Power Station	ZPC	920	1190 (58.4%)
	Munyati (Coal)	ZPC	100	
	Bulawayo (Coal)	ZPC	90	
	Harare (Coal)	ZPC	80	
Bagasse	Triangle (Bagasse)	Triangle Ltd	45	96 (4.7%)
	Hippo Valley Estates (Bagasse)	Hippo Valley Estates	33	
	Green Fuel (Bagasse)	Green Fuel	18	
Wood	Border Timbers (Wood waste)	Border Timbers	0.5	0.5 (0.2%)
TOTAL				2037.25

Solar energy generation is still at an infant stage and is currently focused on rural Zimbabwe and private use (GET-Invest, 2020). As such, this study focused on 58.4% of the electricity used by the case study mines which was considered a result of burning coal in accordance with the electrical power generation proportions of Zimbabwe. According to the Energy Information Administration (EIA, 2020) 2460 kWh of electricity are generated per ton of coal, meaning that 1 kWh is generated by approximately 406g of coal. Therefore, dividing the total electricity used by a mine —in kWh—by 2460 kWh gives the total amount of coal used —in tonnes— to generate the electricity. Multiplying the tonnes of coal used to generate the electricity by the emission coefficient for coal gives the amounts of carbon dioxide emitted in the production of electricity. Therefore, the overall emission coefficients for the fuels recorded at the case study mines are 2.684kg/litre of diesel; 2.348kg/litre of petrol; 0.906 of coal and 906kg/kWh of electricity as shown in Table 11.4.

Table 11.4. Summary of the carbon footprint estimation in accordance with minerals. *(**Source:** Nqobizitha Dube.)*

Mineral	Fuels used (unit) (all electricity usage discounted at 0.584)		Total quantities of each fuel per annum	CO2 Emission coefficients in kgs/unit	Total emissions by fuel type	Total emissions for each mine	Total output in tonnes	CO_2 footprint in kgs / tonne
BNC (Nickel)	Diesel (litres)		60000	2.684	161040	7196374.34	500000	14.39
	Petrol (litres)		14000	2.348	32872			
	Electricity (kWh)	13234567	7728987.128	0.906	7002462.34			
Gold (How Mine	Diesel (litres)		130312	2.684	349757	9736933.03	396000	24.59
	Electricity (kWh)	17741645	10361121	0.906	9387175.63			
Platinum (Mimosa)	Diesel (litres)		2955336	2.684	7932121	139037522	1800000	77.24
	Electricity(kWh)	247500000	144540000	0.906	130953240			
	Petrol (litres)		63641	2.348	149429			
	Coal		3014	0.906	2730.68			
Coal (Hwange colliery)	Diesel (litres)		547500	2.684	1469490	5266340.3	2400000	2.19
	Electricity (kWh)	7176000	4190784	0.906	3796850.3			
Chrome (ZIMASCO)	Diesel (litres)		365000	2.684	979660	2138751.1	100000	21.39
	Electricity (kWh)	2190669	1279350	0.906	1159091.1			
Limestone (PPC)	Diesel (litres)		100000	2.684	268400	7252572.8	1400000	5.18
	Electricity (kWh)	13200000	7708800	0.906	6984172.8			

National carbon footprints for the minerals —shown in Table 11.3— may be estimated using the footprints calculated above. According to the national mineral outputs of the case study, minerals are shown in Table 11.5 alongside the estimated associated CO_2 emissions.

Table 11.5. Estimated annual emissions by mineral. (***Source:*** *Adapted from Mbarawa (2019).)*

Mineral	National annual output (in tonnes) as of 2019	Carbon footprint kgs/tonne	Estimated CO_2 annual emissions in tonnes
Chrome	1 900 000	21.39	40 641
Coal	2 332 000	2.19	5 107
Limestone	323 000	5.18	1 673
Platinum	12 899	77.24	996.3
NickeWl	19 000	14.39	273.4
Gold	27 600	24.59	67.6

Mitigation options

The GHG emissions discussed in the previous sections are apparently well known to the strategic and senior management levels of Zimbabwe's mining industry as shown by the respondents — see Q13-15. When asked to explain how the mines had mitigated climate change, particularly the emission of GHGs, some of the KIs gave responses shown in Q13 -15.

Q13. "At this mine we do environmental rehabilitation, we acknowledge that we harm the environment. We therefore address the impacts we cause, we plant trees and we are currently planting vetiver grass. We also conducted research on the ability of some plants to take heavy metal like lead, mercury. We also encourage use of clean energy in production, solar, electricity, set emission targets, emission testing, environmental auditing, environmental impact assessments (EIAs) for new mining operations or sites, environmental management plans (EMPs)." (How Mine KI, 2020).

Q14. "We set emission targets and adhere to them, we use green technology, use electricity, as well as test and monitor our diesel emissions, and conduct training on environmental and climate change policies." (PPC KI, 2020).

Q15. "We have quarterly objectives that define our targets. We also participate during the national tree planting, environmental campaigns." (Hwange colliery KI, 2020).

In these three examples, respondents concede the harmful effects of mining to the environment and explain that carbon sequestration — using planted trees— and reducing the use of high emissions energy related to fossil fuels are common mitigation measures employed. There is also evidence of emissions accounting through the observance of emission targets — usually set within the organisation — together with the observance of guidelines and plans for emissions mitigation and environmental protection in general. Other environmental control mechanisms that the mining companies engage in are tailings management, dust suppression, and water recycling.

The mitigation options explained in the primary data imply credible foundational knowledge on climate change management through mitigation within the mining sector. Despite this knowledge, platforms that incentivise private businesses to reduce emission — for example, carbon markets, the green climate fund, global environmental facility, and others — are not well known to and understood by the respondents, and by inference, the general Zimbabwean mining space.

Conclusions

The perspectives shown in this study were sought from large mining firms that are at the forefront of mineral production in Zimbabwe. Even though the aim of the study was not to generalise, the information obtained sheds light — from a climate change perspective — on the state of the industry in Zimbabwe and also makes a notable contribution on emissions in accordance with minerals mined.

Results showed a decent level of knowledge on the presence and causes of climate change at the senior management level in the mining sector. Nonetheless, evidence from primary data showed higher concern for current than for future situations. As such, it is critical to engage in awareness campaigns aimed at changing environmental attitudes in the mining sector towards equal opportunity for all generations. It is also critical to improve awareness of market related — and funding — platforms that encourage the reduction of GHG emissions. This would push businesses —

including mines — to prioritise environmental entrepreneurship as environmental management would have immediate benefits supported by the global environmental conservation platforms.

Major climate risk factors revealed in primary data included floods and violent storms that make work dangerous and mining sites inaccessible, droughts that affect water availability and limit the availability of critical ecosystem goods and services like timber, and finally, heat waves that damage equipment and negatively impact on labour productivity. Most of the climate risk identified focused on internal mine activities but failed to consider external risks such as destruction of critical infrastructure — for example, roads, bridges, communication equipment, among others. Such omissions ignore critical risks that should ideally be factored into overall climate proofing in mine plans. In this regard, it is critical to consider broad-based training on climate risk within the Zimbabwean mining sector.

Adaptation options discussed include water recycling, dust suppression, construction of more dams to harvest water using underground reservoirs and tailing ponds, and procurement of more standby pumps to pump water. Further, stockpiling of crushed product, quick movement of stockpiles, and deliberate factoring of wet season delays were also identified as viable adaptation options. Technologies and equipment that is resistant to weather extremes, particularly heat, and training of internal employees in issues of climate change management issues were other adaptation options discussed. The major mitigation options for the mining sector that emerged from the study were carbon sequestration — using planted trees — reducing use of high emissions energy related to fossil fuels, emissions accounting through the observance of emission targets, developing guidelines and plans for emissions mitigation, and environmental protection.

The carbon footprint estimates made in this paper allow for a benchmark that could be used to manage mineral footprints in the future and contribute to a reduction in GHG emissions. Furthermore, it is still necessary for policy makers to push for the use of environmentally sustainable technologies —particularly those with low GHG emissions — in the mining sector.

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Conclusion

Dr. Claude Kabemba and Veronica Zano

There is an appreciation that there exists a global strategy to shift to clean energy. To prevent the most severe impacts of climate change, parties to the United Nations Framework Convention on Climate Change (UNFCCC) agreed on a target of keeping the rise in average global temperatures. Limiting the temperature rise will require substantial and sustained reduction of GHG emissions by all parties, which includes governments, and natural and juristic persons. The 2015 Paris Agreement on Climate Change resolved to embark on development patterns that would significantly reduce GHG emissions.

The impact on the extractive industries is significant. An immediate and radical approach has been advanced aimed at reducing the use of fossil fuels such as coal, oil and gas to achieve a 'net zero carbon' future, which presents some opportunities for the extractives industry. However, the transition to a low carbon economy will require low-carbon energy technologies produced from metals and minerals such as the platinum group metals (PGMs), lithium, cobalt and copper, which are used in the different elements of manufacturing of clean or electric vehicles and solar panels. It is expected that the demand for these metals will increase exponentially in coming years.

The extraction of the above-mentioned minerals carries the risk of further aggravating changes in natural environmental conditions likely to disrupt resource-dependent livelihood generation for local communities yet facing technical and financial resource challenges for efforts to adapt to a changing climate. These challenges further exacerbate the broad range of social, cultural, environmental, economic and institutional concerns that lie at the heart of sustainable development in the continent's extractive industry. The extraction of these minerals is riddled with human rights violations of forced displacements without free prior informed consultations and compensation, pollution, deforestation, biodiversity degradation, inequitable redistribution of returns, lack of transparency in profit sharing and revenue management and corruption.

Whilst the apparent efforts of some mining companies have moved towards reducing the effects of extraction on climate change, it seems there is still need for the industry to take a more robust and proactive approach to climate change action. This should be anchored at identifying potential risks and opportunities from their operations that contribute to the decarbonisation agenda yet at the same time ensuring the sector contributes to economic growth of national economies. Importantly, mining companies should endeavour to make societies and local communities more resilient to the impacts of climate change.

Despite the contribution of extractive industries to climate change, which is clearly demonstrated in this report, the papers demonstrate clear evidence that extractive industries contribute to the increased GHG emissions, which are in turn responsible, to a great extent, for global warming. It is therefore imperative that African governments move with the pace required to introduce strict measures in the extractive industries such as stiffer regulations on water and energy consumption.

The efforts of the mining companies have been on investments towards strategies to ensure they maintain a solid hold on supplying essential raw materials required for climate change, securing profit and supporting new technology applications but not necessarily on protecting their immediate environment from climate change. It is evident that the approach the extractive companies have taken has been quick to focus on the increasing costs of natural resource extraction due to climate change with seldom interest on the risks that their activities will have in the developing countries and local communities in which they operate. The perpetuation and promotion of economic policies and law formulation within post-colonial Africa, while there is rampant poverty, highlights the need for an alternative environmental development and policy formulation pathway that is more socially orientated.

The key conclusion from the studies in this publication is that it is important for Africa to critically draw the nexus between climate change and the extractive industry within the broader sustainable development context. These linkages need to be better understood and incorporated in policy and strategic decision-making by key interested and affected stakeholders. African governments need to be moving in line with this new discourse by investing in research and development aimed at ensuring that this key sector is a catalyst to mitigate and adapt to climate change. They will have to ensure that the extractive industry adapts quickly to contribute sustainably towards climate change mitigation and adaptation on the continent. This can only be realised if investment is made through research and development to understand the impacts of climate change and the implications it has on the continent's development or growth trajectory in general and the specific countries in particular. The impacts should be properly researched and documented. The objective should be to ensure that the transition to a low-carbon economy happens in a 'just' way.

What comes out very clearly through these papers is that the extractive industries' efforts for climate change mitigation and adaptation actions are still at their infancy, especially where law and policy are concerned. The effect of this gap in the region's climate change responses, and particularly in the extractives industry, exposes and weakens all efforts towards the broader sustainable development agenda. It is necessary, therefore, to consider the mainstreaming of climate change in the extractive industry in sub-Saharan Africa (SSA) for sustainable development.

The key conclusion is a call for countries and regional economic blocs to make a radical shift towards improving mining and environmental policies. These policies must be combined in an integrated manner to move towards a resilient and beneficial development for both local populations and the national economy. The need for the extractive industries to shift towards a low-carbon development path and a proactive approach to climate change adaptation is evident.

It has also emerged that most SSA countries have limited capacity to manage the risks and to adapt to environmental, economic and social fallouts they are already experiencing. There is, therefore, need to look at ways in which capacity in addressing the consequences of climate change is enhanced. There is an increasing need for experience sharing and adoption, by African states, of best practices that can be employed to develop an environmental rights sensitive response to the energy and climate crises on the continent. Such cooperation is per the principles of international law and can be a trigger for bilateral and multilateral development cooperation on related terms. However, finding solutions needs to be an inclusive process that should include communities, especially those affected by mining activities.

The Konrad-Adenauer-Stiftung (KAS), Regional Programme Energy Security and Climate Change in Sub-Saharan Africa realizes activities around the nexus of energy security and climate change in Sub-Saharan Africa. One of its priorities is to enhance knowledge development and transfer in the field of energy security and climate adaptation. Given the immense potential of extractive industries to drive growth, support sustainable development and poverty reduction in Sub-Saharan Africa, this publication, which is a compilation of diverse studies, explores the nexus between climate change and extractive industries across the region. It not only advances understanding of the extractive industries but also proposes strategic actions that will potentially lead to more effective climate change mitigation and adaption actions along the production chain in the region.

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