Mining sector challenges in developing countries, Tigray, Ethiopia and inspirational success stories from Australia

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Abstract: The urge to make wealth, reduce unemployment, and improve the living conditions of its people pushes the Ethiopian Government to regulate the mining legislation to favour investment in the sector. The external perception is that some aspects of doing business in Ethiopia are too difficult, and they increase stakeholders' investment's risk and undermine potential benefits. Changes allow for business incentives that include security of tenure, the right to sell minerals, equipment and machinery's preferential duty and tax provisions, a 2%–8% production royalty, a 25% mining corporate tax, custom/duties exemptions, carry forward of losses up to ten years, and profits repatriation's structuring. Ethiopia's resource intensity trajectory is expected to take off in the coming years. However, without adequate mineral discoveries and a competitive extractive industry, it may land up in a 'Catch-22' situation. This hinders the overall progress of the country's development without

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realising the development of the natural resources. This paper highlights the Ethiopian, mining industry status, strategy, and challenges, including 'wirehousing and hotelling', in relation to withdrawal of international companies without completing the mining projects at all stages of projects development (mine to mill), such as exiting during the initial stages of mining industry (i.e., exploration/finding the ore-body), without proceeding to the next stages (mining/extraction/ and transformation/concentration of minerals). Classic contribution of Australia's mining industry to regional development via innovation, advancement, new discovery, capacity, and economy is presented to formulate, scale up/replicate, and appreciate the gap with the defies facing at regional state level (Tigray) and federal level (Ethiopia) and draw a lesson to other developing nations in relation to what a robust sustainable mining sector can bring to nation's economy through different themes. This article has heaps of takeaway messages and has brought up untold embedded issues, which can be an inordinate input to diverse background of miners, mining companies, financiers, stakeholders, and governments' decision makers, and will be well received by global readers.

Keywords: mining industry and natural resources; minerals and metals; oil and gas; mining legislation; developing countries; Africa; Ethiopia; Tigray; Australia; business incentives.

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1 Introduction

Mining companies have been involved at a corporate governance level in many countries around the world (ICMM, 2012a, 2012b; Gunarathne et al., 2016; Suopajärvi et al., 2016). It is believed that recent approaches, experiences, and the successes of mining companies' past undertakings could add tangible value to the countries where mines are found (Boadi, 2016; Ghorbani and Kuan, 2016; Xiao et al., 2017).

While every country is different and has different cultures and criteria for foreign investment and project development, this study mainly reviews approaches that embolden and discourage foreign investment. External perception is that some aspects of doing business in a country are too difficult, increase investment risk, and undermine the potential benefits to all stakeholders (Jordan, 2009; Tiainen et al., 2014; Suopajärvi et al., 2016; Tiainen, 2016; US Department of State, 2016). This study discusses how this may be refined and changed to encourage foreign investment in a country and, importantly, expedite project development through to production and value added to the secondary industry.

This study investigates the mining industry in Ethiopia, as it is enriched with plenty of minerals, mines, and hydrocarbon resources. Recently, multi-national mining companies also have been involved globally in the development of new mineral resources' projects in Ethiopia and have benchmarked this experience to their findings, based on their first-hand knowledge of the gold, tantalum, gemstone, and Danakil region' potash projects' development in the country.

Mining companies' interest is to potentially establish a multi-commodity opportunity, successfully exploit the mineral from the in-situ mineralisation and the waste dumps (Govindan et al., 2014; Petkova et al., 2014; Govindan et al., 2016).

Foreign investors into Africa continue to seek the 'next wave' of sectors beyond consumer-facing ones, with increase/decrease in Foreign Direct Investment's (FDI)

projects. South Africa was the largest destination, with 95 FDI projects in 2015, followed by Kenya, Morocco, and Egypt, while Ethiopia ranked 8th (Table 1).

Companies already undertaking business in Africa will continue to invest, but will undoubtedly exercise a greater degree of thoughtfulness and be more sensitive. It is believed that any shorter term changes in FDI levels (example, between 2014 and 2015: Table 1), will be recurring rather than structuring. It is predicted that the evolution of FDI will continue, specifically in relation to growing diversification. Several African economies will continue to mature as financial recovery happens gradually. Moreover, it is forecasted that levels of FDI will remain strong and will continue to propagate.

Table 1 Top 15 destination countries by FDI projects (2015), Ernst Young (EY) Africa FDI destination

Number of FDI projects								
Rank	*Country*	*2015*	*2014*	*Change*		*Share (%) 2015*	*FDI share (%)*	*Jobs created (share in %)*
				%	*Change*			
1	South Africa	95	120	8.30	Increase in FDI	16.90	6.80	8.80
2	Kenya*	74	62	53.20	Increase in FDI	12.30	3.60	8.00
3	Morocco	66	67	10.40	Increase in FDI	9.60	6.30	17.40
4	Egypt	53	59	11.90	Increase in FDI	8.60	20.50	8.60
5	Nigeria	41	49	8.20	Increase in FDI	6.90	12.10	9.20
6	Ghana	32	39	5.10	Increase in FDI	5.30	2.00	1.50
7	Mozambique	30	50	36.00	Decrease in FDI	4.20	7.20	7.10
8	*Ethiopia*	28	32	6.30	Decrease in FDI	3.90	2.50	9.70
9	Cote d`Ivoire**	24	15	86.70	Increase in FDI	3.60	5.00	3.30
10	Uganda	23	23	4.30	Increase in FDI	3.10	6.50	1.40
11	Tanzania	15	20	15.00	Increase in FDI	3.00	1.90	1.60
12	Cameroon	13	8	87.50	Increase in FDI	1.90	2.60	0.90
13	Tunisia	13	11	18.20	Increase in FDI	1.70	0.60	1.30
13	Algeria	13	13	0.00		1.70	1.10	2.50
13	Rwanda	13	11	18.20	Increase in FDI	1.70	1.70	1.20

Notes: *Kenya becomes bigger gainer with year-on-year FDI project numbers growing by over 50%. **Cote d`Ivoire enters in the 15 top list.

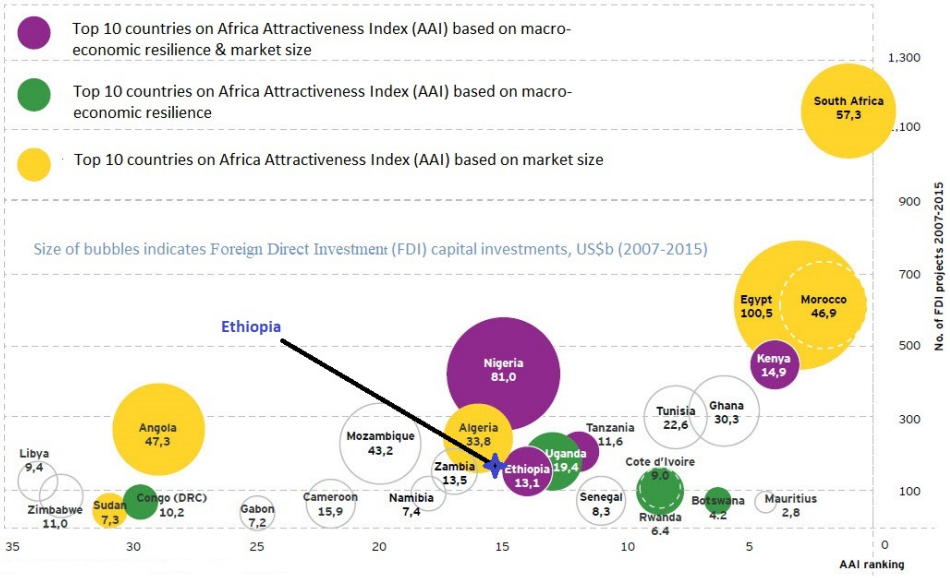
Source: https://www.ey.com/za/en/issues/business-environment/ey-africa-attractiveness-program-2016-staying-the-course

East Africa rests the most resilient of all, with the four strategic economies (Kenya, Ethiopia, Tanzania, and Uganda) all dignified for growth of greater than 5% for the coming decade. Ethiopia is among the top ten countries on Africa's Attractiveness Index (AAI) based on macro-economic resilience and market size (Figure 1).

This study is a snapshot of the mining industry in Ethiopia, summarising briefly recent legislative reforms and initiatives in the mining sector. It includes mining code requirements and some of the practical issues that may be faced by investors. The aim of this study is to highlight and overview the challenges in the mining sector happening in developing countries, with Ethiopia (Tigray) as a case study. It is important for our approach to analyse the current 'gap' in order to clearly understand the country's

approach and criteria for foreign investment, and how this can be understood externally and would be deployed by investors (Yihdego and Kwadwo, 2017). In line with this, experience from Australia with the role of its mining industry as a successful economic drive, and lessons drawn from it as a takeaway message is presented.

Figure 1 Ernst young (EY) Africa investment attractiveness matrix (see online version for colours)



Note: Size of the bubbles indicates FDI capital investments, US$ billion (2007–2015).

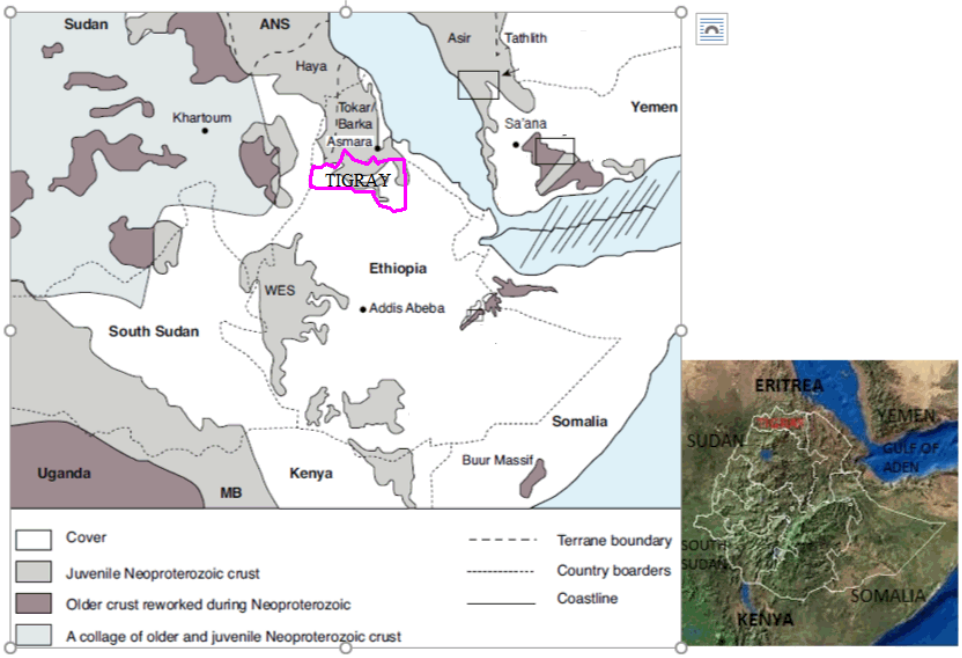
Source: FDI markets and EY's Africa attractiveness index; https://www.ey.com/za/en/issues/business-environment/ey-attractiveness-program-africa-2017

2 Study area

Ethiopia is situated in east Africa, in the region termed the Horn of Africa (Figure 2). With a population of 100 million, Ethiopia is the most populous landlocked country in the world, as well as the second-most populous nation on the African continent after Nigeria. It occupies a total area of 1,104,000 km^2. The country's topography is predominantly comprised of high plateaus. In less elevated regions, particularly the lower lying Ethiopian grasslands and shrub lands in the east of the country, the climate can be significantly hotter and drier. Dallol, in the Danakil's Depression in this eastern zone, has the world's highest average annual temperature of 34ºC (https://en.wikipedia.org/wiki/Ethiopia).

Ethiopia has its fair share of challenges not only for investors, but also for the Ethiopian Government (federal and regional states) and local communities. Ethiopia is one of the poorest countries in the world, with a very low per-capita income and high rates of unemployment. Currently, Ethiopia's economy revolves around agriculture.

Figure 2 Map of Ethiopia (courtesy of Google earth – right) (see online version for colours)



Notes: Regional state of Tigray with approximate pink line/red text. Precambrian exposures of the Arabian-Nubian shield. Inset shows the East African Orogen consisting of the Arabian-Nubian shield: north, western and southern Ethiopian shield.

Source: Modified after Yeshanew (2017) – left figure

2.1 Tigray regional state

The Tigray region is the northernmost of Ethiopia (shown in Figure 2), and comprises ~54,000 km^2. It is bordered by Eritrea to the north and Sudan to the west. Tigray has a population of about 6 million, repeatedly cited in civilisation, historic, and cultural lists of humanity (such as Axum obelisks and Ark of the Covenant). Tigray has got rich mineral resources, which include gold, copper, silver, iron, zinc, lead and nickel, as well as oil shale (Yihdego et al., 2018a). Asbestos, silica sand, kaolin, graphite, gypsum, gemstone, marble, granite, slate, limestone, and dolomite are among the non-metallic minerals that also exist in Tigray.

2.2 Geology

Rocks of Precambrian age underlie large parts of northern and western Ethiopia and smaller areas in the south and east of the country (Figures 2 and 3). The Precambrian geology is poorly understood pending modern investigations but appears to comprise Archean to Proterozoic metamorphic rocks. Ethiopia lies at the northern tip of the continental part of the East African Rift System. Voluminous piles of mainly Cenozoic

volcanic rocks occur in large parts of western Ethiopia. Mesozoic and Cenozoic sediments occupy the eastern parts of the country, unconformably overlying the Basement. The Rift Valley is covered with relatively young lacustrine sediments and volcanics. Volcanic rocks are more extensively developed in Ethiopia than anywhere else in the East African Rift System and are most thickly developed in the central region and along a N-S axis situated immediately west of the main rift. The volcanics are characteristically alkaline, typified by fissure basalts of the trap series which can reach 2,000 m in thickness at the plateau-rift margins.

3 Mining in Ethiopia

Mining is important to the economy of Ethiopia as a diversification from agriculture. Gold, gemstones and industrial minerals are important commodities for the country's export-oriented growth strategy. Tantalum mining has also been profitable.

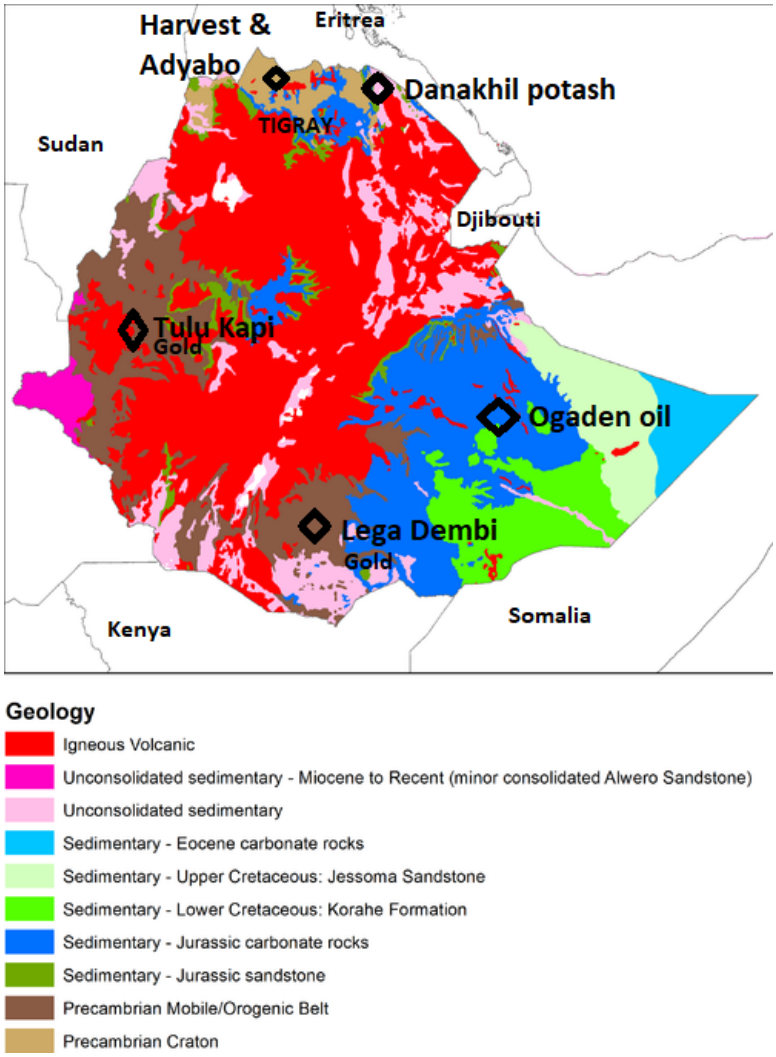
New mining regulations were issued in 2010, in replacement of the 1993 law, intending to promote the exploration and development of Ethiopia's natural resources. This country is endorsed with underdeveloped hydrocarbons' and minerals' wealth, which provides an opportunity for future economic development and is envisaged as a possible significant economic driver for the country.

Ethiopia has most of the essential elements required for success as a mining nation. It is resource-rich, with a vast breadth of undeveloped minerals and other natural resources, including significant gold and tantalum deposits. Petroleum and gemstones have also been identified. A proven reserve of natural gas has been found which is ready for commercial exploration, whilst deposits of platinum, tantalite, iron, copper, lead, zinc, nickel and other base metals do also exist. Industrial and construction minerals, such as quartz, feldspar, mica, kyanite, kaolinite, talc, chromites, graphite, magnesite, industrial olivine, marble, granite, potash, rock salt, soda ash, sulphur, silica sand, diatomite, and bentonite, have been identified and some are under production. If such a mineral wealth is combined with a skilled and highly motivated workforce, it will guarantee a thriving and profitable mining sector. The Mining Proclamation recognises the significant role of private investment in capital formation, technology acquisition, and marketing of minerals.

Positioned in the Horn of Africa, Ethiopia is also strategically located for foreign investment from Europe, Asia, and Australia, as it is fairly attractive to investors. Indeed, its mining code has been designed to promote transparency and fair investment in Ethiopia and is similar to the best practices of well-known mining countries. Public enterprises continue to dominate Ethiopia's developing economy, but the potential for private investment remains largely untapped.

The mineral sector was opened up to private investors in 1991 with new legislation and the Mineral Operations Regulations in 1994, which helped to create an environment conducive to private investment. The development of Ethiopia's mineral wealth is one of the government's leading economic objectives, which serves as one of the catalysts for the export-orientated development strategy in place. Geological surveys indicate that Ethiopia is endowed with a variety of mineral resources.

Figure 3 Geology of Ethiopia with key mining projects (see online version for colours)



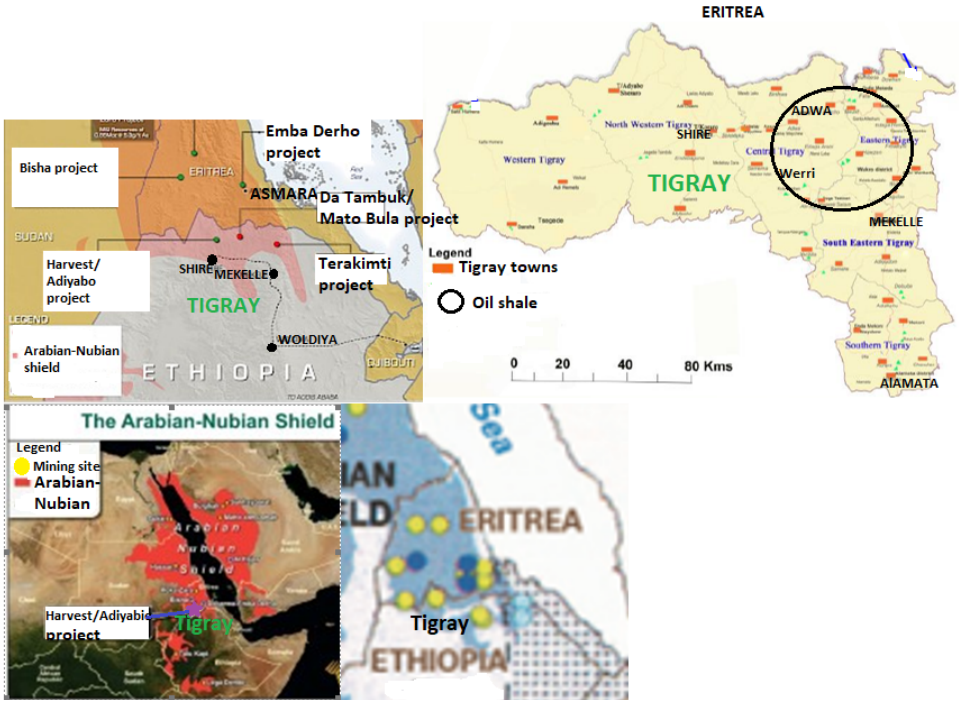
Source: Modified after Persits et al. (2002)

The Ministry of Mines, Petroleum and Natural Gas (MoMPNG) has granted 200 mineral exploration licenses since 1992. Ethiopia's minerals sector contributes less than 1% to the country's GDP. Ethiopia's main mineral export is gold. In 2008, gold production increased by 10% for the country to become the 9th largest producer in Africa. Silver production increased by 19.5% for the same period. Ethiopia is the 5th largest producer of tantalum in Africa (8.2%) and accounted for 4% of global production. The country is a relatively small producer of natural soda ash, salt, gypsum, opal, kaolin, feldspar, and construction materials. Ethiopia additionally has small reserves of platinum, copper, potash, lignite, crude oil, shale oil, and natural gas. In 2011–2012, the mining sector earned US$618 million from mineral exports – two-thirds coming from artisanal mining. The mining sector is expected to generate US$2 billion by 2024, employing 8,000 citizens.

3.1 Mining in Tigray regional state

A geoscientific map for geology and mineral resources of Tigray (Figure 2) is shown in Figure 3 (see Figure 4 for more details). Metallic resources (precious, rare, base and ferrous-ferroalloy metals) are widely related to the metamorphic meta-volcano-sedimentary belts and associated intrusive, belonging to various terranes of the Arabian-Nubian Shield (Yeshanew, 2017). Industrial minerals and rock resources occur in more diversified geological environments, including the proterozoic basement rocks, the late paleozoic to mesozoic sediments, and recent volcanics and associated sediments. Energy resources (oil, coal, geothermal resources) are restricted to phanerozoic basin sediments and cenozoic volcanism and rifting areas (Theart et al., 2018).

Figure 4 Tigray and neighbouring country (Eritrea) key mining projects (see Figures 2 and 3 for the basement and geology of Tigray, Ethiopia) (see online version for colours)



4 Security, sovereign risk, regulatory framework, mining license/permit requirements, and mining taxation

4.1 Security

During the 1990s, the Ethiopian Government revamped its mining law and regulations and began upgrading infrastructure to support mining. In 1993, the Mining Proclamation and the Mining Tax Proclamation was put in place to provide a legal regulatory

framework to promote investment in mineral exploration and production in the country. These proclamations were followed by additional amendment proclamations until 1996, marking a major shift from the government's monopolised mining sector that existed prior to 1993. The proclamations allow for business incentives that include security of tenure, and the right to sell minerals.

Most of the time, the mineral/ore body region is remote and security is sometimes an issue. In addition to this, normal cultural respects and cautions must always be understood and exercised. There are also incursions linked to extremists or the presence of warlords. Despite these, the Tigray Regional State enjoys a peaceful situation, emanating from the people's culture, organisational capacity and discipline. Any work undertaken would be conducted with the full knowledge and support of the MoMPNG, and security intelligence should be provided.

4.2 Sovereign risk

The Fraser Institute's Survey of Mining Companies in 2015, ranked, the country 8th (amongst 20 African jurisdictions) for overall investment attractiveness, with a score of 64%, placing the country 51 out of 109 ranked countries, globally. This represents an impressive improvement from 89/122 in 2014.

4.3 Regulatory framework

The regulatory framework of the mining sector in Ethiopia is dealt-with through several legislative arms. The 1995 robust constitution of the country exclusively vests ownership of all natural resources in the country. The main organ which regulates the mining sector is the MoMPNG. This government instrumentality has, among other things, the power to issue licenses to private investors engaged in exploration and mining operations. At the regional level, there are also mineral, water, and energy bureaus.

Stakeholders in the Ethiopian mining regulations include the MoMPNG, the Geological Survey of Ethiopia, and the Environmental Protection Authority, as well as regional mining agencies. The Ministry of Environment and the Ministry of Labour are also key ministries for the mining industry in Ethiopia. While the former regulates the environmental aspects, the latter ensures safety in the work environment. Other ministries, like that which is involved in business registration, are also to be considered.

The country's mining laws constitute the following proclamations: Mining Operations Proclamation No. 678/2010, and Mining Income Tax Proclamation No. 53/1993, as amended in Proclamation No. 23/1996. The Mining Operations Proclamation governs all mining and related activities in the country. Mineral resources of the country are the property of the State and the people. The government – custodian of mineral resources – acts through the licensing authority to control and administer mineral resources. Mining activities are opened for private investment and the mining law provides for legal safeguards for tenure security. Licensees are required to give preference to the employment of Ethiopian nationals having the required qualifications, and give preference to domestic goods and services, where they are readily available at a competitive price and comparable quality.

Ethiopia opened its mining sector to private investors in 1991. Recent legislative reforms and initiatives have focused on further encouraging investment in the mining sector.

The recent enactment of the Mining Operations Proclamation No. 678/2010, which came into effect in 2010, revised mining laws in Ethiopia by broadening the range of mining licences available. The proclamation confirms the requirement for environmental impact assessment (EIA) and regulates health and safety matters. New legislative incentives have been introduced. These include lower royalty payment levels, exemption from customs duty and taxes on mining equipment, guarantees in respect of the right to sell minerals locally or abroad and the availability of disputes' resolution procedures, such as arbitration.

4.4 Mining license/permit requirements

Five types of key licences issued by the licensing authority are summarised as follows:

1 Non-exclusive reconnaissance licence, which is valid for up to 18 months and is not renewable. It requires sufficient financial resources and technical ability to conduct the proposed exploration, the estimated expenditure complies with the prescribed minimum exploration expenditure and the environmental impact plan that is approved.

2 Exploration Licence, which is valid for up to three years and may be renewed twice for a period of up to one year each, with a license maximum duration of five years. The licensee has the right to apply for and be granted a retention licence or a mining licence.

3 Retention licence, which is granted for up to three years and can be renewed for up to other three years. Applicants must demonstrate the discovery of a mineral deposit which is of commercial significance, but cannot be developed immediately because of adverse market conditions or unavailable processing technologies. The licensee has the right to be granted a mining licence prior to the expiry of the retention licence.

4 Small- and large-scale mining licences, which are granted to applicants where the proposed work program is approved, have access to financial resources and technical ability to conduct the proposed mining operations and the EIA has been approved. A small-scale licence is valid for up to ten years and may be renewed for up to other five years. A large-scale mining licence is valid for up to 20 years and may be renewed for up to other ten years.

5 Artisanal mining licence, which provides an exclusive right to explore and mine for the minerals within the licence area. A licensee shall be obliged to undertake mining operations according to the environmental, health, and safety standards prescribed for artisanal mining in the relevant laws. This type of licence is valid for up to three years and may be renewed twice for three years each.

4.5 Mining taxation

Mining in Ethiopia is governed by the independent legal regime. Investment and income tax proclamation does not apply to mining activities. From the last decade, several amendments and re-enactments were made to the mining law, driven by the growing demand for metallic and industrial minerals and the need to create highly competitive

legal frameworks for mining investments. The Mining Income Tax Proclamation No. 53/1993, as amended (Proclamation No. 23/1996), governs taxation of mining activities. Holders of mining licenses are required to pay royalty based on the scale price of the commercial transactions of the minerals produced. The rate of payment ranges from 8% (for precious minerals) to 2% (geothermal). Holders of large-scale or small-scale mining licenses pay tax at 25%. Artisanal mining is exempted from income tax.

Taxable income is computed by subtracting from gross income for the accounting year in question all allowable revenue expenditure, depreciation, reinvestment deduction, and permitted losses. Income taxes are calculated for each accounting year and paid within 90 days after the end of such year. Tax is payable on dividends declared and distributed from taxable income after deduction of income tax. The tax on dividends is imposed at a rate of 10%. The licensee is the withholding agent and is required to pay the tax within 60 days after the distribution of dividends. The will of the Ethiopian Government to come up with a robust mining policy and related regulations, and to attain transparency and protect local and foreign investors is considered a positive gesture.

Also, the intended future plan of reducing mining corporate tax from 35% to 25% (with breaks and holidays) will potentially attract foreign mining companies. Besides to the royalty at discretion of ministry, customs and duties exemptions available on equipment, machinery, vehicles, and spare parts required for mineral operations, carry forward of losses up to ten years, which derive an increasing number of international firms registered in exploration (C2D Services Inc., 2013).

5 Outlook of the mining industry, operation and investment

Ethiopia has reserves of gold, platinum, copper, potash, gemstone (sapphire and emerald), oil and natural gas, as well as shale oil produced from oil shale (Yihdego et al., 2018a). The mining industry in Ethiopia is growing with a major involvement of the private sector. However, the mineral industry is not a significant sector of the economy, contributing less than 1% to the Ethiopian economy, which is expected to reach 10% in ten years' time.

The investment policy of Ethiopia is generally established under the principle and practices of a free market driven economy. The government has enacted a very competitive legal and fiscal regime that attracted many local and foreign mining companies to involve in the mineral operations, starting from exploration to mining activities. These laws have been amended consistently to make them more competitive.

The investment in the mining sector is persistently growing, and revenue generation from this sector is also increasing, accordingly. Ethiopia earned US$654 million from the export of minerals, including gold, platinum, tantalum, decorative stones, and gem stones, in 2011/2012, according to data from the MoMPNG. This was largely accounted for by gold, of which 12 tons were exported for a total of US$602.4 million. MIDROC Gold Mine exported close to three tons of that total. The Government of Ethiopia is intending to manage all necessary revenues generated from the mining sector in a transparent and accountable manner. Other key mineral products of Ethiopia include niobium, platinum, tantalite, cement, salt, gypsum, clay and soda ash.

Mining companies seek expressions of interest from international parties to joint ventures that will ultimately develop the mineral resources into fully operational concerns, as well as exploit the primary mineral resources.

As a result of the conducive fiscal and legislative environment, the country is commencing the participation of both foreign and local investors in exploration and mining. To date, the MoMPNG has granted about 119 exploration licences of which 86 are foreign and 33 on joint venture basis, and 52 mining licences of which 24 are foreign, 17 are on joint venture, and 11 locally owned. The total number of licences issued has reached 171 granted to 86 companies. These are for gold and base metals, platinum, industrial and construction minerals, notably; potash, diatomite, and high quality ceramics raw materials. Intensive exploration programs are also being conducted for oil and gas, precious stones such as diamonds and sapphires, and other gemstones in different parts of the country.

Exploration that was oriented towards the assessment of the mineral and petroleum resources has been conducted both by the Ethiopian Geological Survey (EGS) and private companies. These geological studies have resulted to significant discoveries of gold, tantalum, phosphorus, iron, salt, potash, soda ash, gemstones, coal, geothermal energy, natural gas, industrial and construction minerals and rocks in different parts of the country. The mineral resources of Ethiopia are yet untouched and so the country has sufficient potential to accommodate the interest of so many other investors (C2D Services Inc., 2013).

The urge to make wealth, reduce unemployment, and improve the living conditions of its people by increasing the contribution of the mining sector to the GDP pushes the Ethiopian Government to regulate the mining legislation to favour investment in the sector. As already said, the continuous improvement of the mining law, transport facilities, and many other factors has brought about a significant improvement in its classification in the Fraser Institute's Survey of Mining Companies 2015 (Table 1 and Figure 1).

Foreign companies already investing in Ethiopia's mining sector come from all over the world, including the UK, China, South Africa, Canada, the USA, Guyana, Italy, and Norway. In 2009, foreign investment in the mining sector amounted to US$1 billion. There has been a recent spike in interest, with reports of investors from China, India, Germany, Australia, Sweden, and South Korea – each actively seeking to become a key stakeholder in upcoming mining projects in Ethiopia. For example, mining giants Vale S.A. and BHP are already working on projects near the Oromia region and actively exploring for further gold reserves and base metals, such as silver, copper, cobalt, and zinc. Vale S.A. is a Brazilian multinational corporation engaged in metals and mining and one of the largest logistics operators in Brazil. Vale S.A. is the largest producer of iron ore and nickel in the world, and is currently working in Ethiopia on gold mining and exploration. BHP, formerly known as BHP Billiton, is an Anglo-Australian multinational mining, metals, and petroleum dual-listed public company headquartered in Melbourne, Australia.

Additional exploration has confirmed the presence of deposits of platinum, tantalite, soda ash and phosphate rock. Petroleum and other metallic, industrial and chemical minerals have also been identified. The MoMPNG of Ethiopia (the 'licensing authority'), which is responsible for issuing licences and regulating mining activity, has confirmed there has been a recent increase in applications for exploration licences.

The main features of the Mining Operations Law, which came to effect in August 2010, are:

1 Invites private investment for all kinds of mineral operations.

2 Provides no more than 18 months non-exclusive reconnaissance license.

3 Provides no more than three years exclusive exploration license with two renewals of one year each.

4 Provides no more than three years exclusive retention license with one renewal of not more than three years if the applicant demonstrates the discovery of a deposit of commercial significance and which cannot be developed immediately.

5 Provides exclusive small-scale and large-scale mining licenses for no more than ten and 20 years, respectively, with unlimited renewals.

6 Requires adequate health, safety, and environmental protection, as well as EIA studies.

7 Provides inclusion of minerals, which were not originally specified in the license as they are discovered.

8 Guarantees the licensees right to sell the minerals locally or abroad.

9 Provides exemption from custom duties and taxes on equipment, machinery, vehicles, and spare parts necessary for the mineral operations.

10 Provides the opening and operation of a foreign currency account in banks in Ethiopia.

11 Retention of portion of foreign currency earning and remittances of profits, dividends, principal and interest on a foreign loan out of Ethiopia.

12 Government can acquire up to 5% equity on small- and large-scale mining operations for free.

13 Provides for disputes' settlement through negotiation and arbitration.

5.1 Minerals

Recently, significant and well-defined orogenic gold and volcanogenic massive sulphide (VMS) deposits are also outlined by private companies in the Western and Northern Greenstone Belts of the country. There is a small-scale tantalum mining operation, called Kenticha Tantalite Mining, hosted in the pegmatite rocks of the Southern Greenstone Belt. Huge industrial and construction raw materials occur in various kinds of rocks, varying in age from Precambrian to recent, and existing in different parts of the country.

5.1.1 Gold (and base metal)

Gold occurrences are widespread in Ethiopia and exploitation of placer gold dates back at least 3,500 years, where the Egyptians sailed along the Red Sea and travelled up into what later became Ethiopia to trade gold. Gold has been produced from placer deposits mainly by the artisanal miners roughly 7–8 tons of gold per annum (C2D Services Inc.,

2013). Gold is considered to be the mineral with the most potential for mining investment and the Government estimates that production could rise to 40 tons a year given sufficient investment. A recent survey increased estimates of gold resources to 500 tons. Production could rise to 40 tons a year from just over four tons last year, earning the country around US$1.7 billion at current prices, by the following list of mining sites to mention among:

a MIDROC Gold Mine plc. operates the Lega Dembi mine (Figure 2), in southern Ethiopia. Production averages four-ton gold per year. It is an open pit operation and reportedly has reserves of 7,000 kg gold. Drilling of the Sakari deposit indicated a resource of 17,250 kg of gold (MTG, 2017).

b National Mining Corporation announced a mineable gold discovery at Dawa Dagiti in southern Oromia region. The company was also studying evidence of large silver deposits in the Tigray region.

c Nyota Minerals Limited is focused on the exploration and concurrent development of Tulu Kapi (Figure 2), in western Ethiopia. Nyota applied in May 2011 for a ten-year license to start mining on 11,000 km^2 area. Minerva Resources plc. is drilling extensions of mineralised zones at Tulu Kapi. The International Finance Corporation (IFC) – a member of the Work Bank Group – has made US$4.4 million investments in Nyota to help finance the development of the property.

d WCP Resources Ltd. has explored the Agusha-Gumu Dunga area located 5 km to the northwest of Asosa, western Ethiopia.

e Avion Resources Corporation purchased the exploration assets in the northern (Tigray Regional State, 2,674 km^2) and western regions of Ethiopia (1,766 km^2).

f Alecto Minerals plc. holds a 1,953 km^2 Aysid-Metekel gold exploration licence in the prospective Aysid-Metekel region of north-western Ethiopia, 600 km from the capital city, Addis Ababa.

g Sheba Exploration plc. explored the Amora Hill gold prospect in 2005 (Merwe, 2018).

5.1.2 Platinum

Minerva Resources plc., through its subsidiary Golden Prospect Mining Company (GPMC), owns 51% of the Yubdo Gold and Platinum Mining Company (Yubdo Mining), Ethiopia. It is a small-scale operation, currently producing approximately 100 ounces of platinum a year. The Yubdo mine is 520 km almost due west from Addis Ababa. Annual production is expected to increase to a rate of over 500 ounces per annum. GPMC estimated a resource of 793 kg of platinum in 1,470,000 tons of laterite material with an average grade of 0.54 g/t platinum. The average grade of the laterite below a barren 1.5 m soil layer was 0.82 g/t platinum (Merwe, 2018).

5.1.3 Tantalum

Ethiopian Mineral Development Tantalum mine produces around 200 tons of raw tantalum per year, yielding revenues of around US$25 million. Since 2013, the Ethiopian Government banned exportations of raw tantalum, which is supposed to be concentrated

in the country (value-added bid). The investment needed for building a processing plant is presently estimated at US$30 million (C2D Services Inc., 2013). On a global scale, Ethiopia is a significant producer of tantalum, producing 7% of the world's supply in 2007 (EAM, 2018a).

5.1.4 Graphite

Graphite occurs in the Moyale area, located 750 km south of Addis Ababa, on the Kenyan border. Graphite occurrences in the Moyale area are hosted by quartzite, quartz-feldspar-mica schist, and rarely by amphibole schist. The average grade of the Moyale's graphite schist ranges between 7% and 11% (mean 9.1%). The Moyale area contains an indicated mineral resource of about 450,000 tons of graphite (Merwe, 2018).

5.1.5 Potash and phosphates

Potash has been mined in the former Tigray's Dallol area in Ethiopia since the 14th century. Yara Dallol BV – a subsidiary of Yara International – has already undertaken a feasibility study for the potash exploration project in the Afar Regional State (Figure 2). The estimated capacity for the Dallol project is 1.0–1.5 million tons of potash per year, with resources of more than 30 years mining. Yara hopes to supply 10% of the current global potash market. Allana Potash of Canada is also in the process to build a potash mine in the Dallol depression. The company secured a mining license from the Ethiopian MoMPNG. A local company – Ethio-Potash Corporation – is also exploring the Dallol depression. Allana Potash is a publicly traded corporation which focuses on the acquisition and development of potash assets internationally, with its major focus on a previously explored potash resource in Ethiopia and controls 160 km^2 of the Danakhil Depression. China Investment Corporation is considering investing in the project (Merwe, 2018).

5.2 Oil and natural gas

Ethiopia's current proven hydrocarbon reserves are minimal, but the potential to increase reserves to commercial viability is seen as promising. The country's geology is similar to that of its oil-producing neighbouring countries to the east (on the Arabian Peninsula) and the west (Sudan). The MoMPNG reported that hydrocarbon seeps had been discovered in several regions, besides to the oil shale potential (Yihdego et al., 2018a). The government plans to conduct feasibility studies to establish the extent and viability of the deposits.

Ethiopia has a large potential for geothermal energy resource with several targets outlined within the East African Rift System. There are three gas field discoveries, called Calub, Hilala, and Genale gas fields in the Ogaden Basin (Figure 2), in the south-eastern part of the country. These gas fields contain a total of about 4.6 trillion cubic feet (TCF) gas (https://en.wikipedia.org/wiki/Mining_in_Ethiopia). Meanwhile, at stake are an estimated eight TCF of natural gas in the Ogaden Basin, where exports are due to begin in 2021 via a pipeline to neighbouring Djibouti. GEP plans to construct a 600 km, 61 cm pipeline to transmit natural gas to the town of Awash, 120 km east of the capital Addis Ababa. Form the region's energy resources, including natural gas reserves; the Government will eventually earn US$7 billion a year (Manek, 2018). Petronas (a Malaysian oil and gas company) is also interested in natural gas exploration in Ogaden.

In June 2003, the Ethiopian Government signed an oil exploration deal with Petronas for 14,900 km^2 tract in Gambela, in the far western part of the country. The region is closely related to the Sudan's oil fields (Merwe, 2018).

5.3 Mining status in Tigray Regional State

There are no large-scale mining companies in this region except:

a A giant US gold mining company – Newmont – which is developing a large-scale gold mine jointly with Ezana Mining Development (an Ethiopian company) in Shire, North-western zone of Tigray, Ethiopia. Newmont Mining Corporation, based in Colorado, USA, is one of the leading gold mining firms in the world.

b Cement, marble, gypsum factories.

Indeed, there are many companies doing exploration in the Tigray region, which have got licenses to operate in exploration of gold, base metals, industrial minerals, coal, gemstones, and other ores and minerals. Foreign and local mining firms are involving in different parts of the Tigray region. These include mining companies from Saudi Arabia, China, the USA, Canada, the UK, Egypt, etc.

Also East Africa Metals is actively involved in Adyabo Gold Project, Tigray (Figure 4). East Africa Metals is a Vancouver-based (Canada) mineral exploration company, focusing on exploration and development projects in Africa. The company has received approval for a Mining Licence at Harvest (Figure 4), and is under application for two mining licences at Adyabo (EAM, 2018b).

Recently, East Africa Metals received draft model agreements (DMAs) from the MoMPNG for the company's Mato Bula and Da Tambuk projects (Figure 4). Their permit was approved for Ethiopian gold projects. The delivery of the DMAs indicates the Ministry (MoMPNG) has approved the permit's application and advanced the permitting process to the next stage (MRF, 2018).

The Mato Bula project has an average annual metal production of approximately 34,750 ounces (oz) gold, 1.67 million pounds' copper and 4,780 oz silver. The Da Tambuk project has an average metal production of 24,000 oz gold per year and 6,000 oz silver per year. A processing rate of 1,400 tons and 550 tons per day is estimated for Mato Bula and Da Tambuk, respectively. Also, eight year and four-year mine life is estimated for Mato Bula and Da Tambuk, respectively (MRF, 2018).

The National Mining Corporation (NMiC) announced the discovery of the largest gold and base metal reserves in the Tigray Regional State. The gold reserves discovered at Werri (Figure 4), central Tigray, have estimated gold reserves of 18,000 kg expected to be worth US$792 million. The new discoveries in Werri of Tigray would make NMiC earn over US$4 billion in 20 years. The mining company has also discovered other minerals, including zinc, silver, and lead. The projects are expected to be technically and economically feasible (Mining, 2012).

Earlier on, ASCOM (an Egyptian company), announced the acquisition of gold concessions in Tigray near Eritrea. The concessions, located on four different plots of land, are owned by a newly established company called Nubia Mining Development plc.

Avion Resources Corporation (Canadian) exploration asset covers approximately 2,674 km in the Regional State of Tigray, where massive sulphide zones, including Bisha

deposit, Eritrea (immediate north of Tigray), and several gold deposits have been discovered in these greenstone belts.

Huge deposit of most precious gemstone Sapphire was found in the Tigray Regional State. The deposit is found in central, western, and north western of Tigray. Newly discovered (late 2016), the precious gemstones (sapphire) in Tigray, is generating many millions of dollars. Blue sapphire is the most desirable gemstone next to diamond, due to its excellent blue colour, hardness, durability, and luster (TOL, 2017). In the world market, the polished blue sapphire is sold at a price of up to US$15,000 a carat, depending on the quality and grade of the gemstone.

The exported sapphire is blue, and it is extracted from two districts/Weredas namely in Mereb Leke (at Awet, Tila and Hadush Simehden locality), and Lailay Maichew (at Medego locality). It has created job opportunity for 10,000 people living in the area, involved in the extraction of the mineral in the region. The gemstone is currently extracted by artisanal miners who are structured in unions and cooperatives. However, the extraction has not yet entered into a well-organised system, as farmers from the area are currently extracting it (C2D Services Inc., 2013).

6 Practical issues facing the mining industry

Apparently, the mining cycle is a long-term investment which requires real commitment and often brings a lot of challenges over the period of phases, as follows:

- Up to ten years for exploration (success probability of the investigated site to become an actual mine is < 5%, implying the risk of loss). The mining sector is mostly at early stage of exploration. More than 300 licenses have been attributed by the MoMPNG. Around 25–30% of these licenses were endorsed to international mining firms. However, it is impossible to assess the intensity of real exploration being actually done in Ethiopia, being the MoMPNG does not disclose the list of license owners nor the actual work done and money spent on these properties.
- Up to two years for scoping and feasibility study to determine the actual value of the ore deposit, the mining method that will be used to extract the ore, the capital cost needed to commence the mine, operating cost, the equipment and workforce needed, and time line for the mine, with the overall success probability being approximately 10%.
- Up to two years for financing (i.e., process of getting the necessary funds and cash flows to construct the mine and operate it). Success probability is approximately 20%.
- Up to several years for licensing to obtain all necessary permits/authorisations from the government (local, regional and federal), depending on the complexity of the project and its environmental and social impact, as well as political stability, etc.
- Up to two years for construction and initial development. This phase consists in building civil and mining infrastructures (access roads, offices, workers' living site, waste piles, tailing dams, underground ramps and/or shafts, electricity lines or power plant, concentration mill, etc.).

- Up to 100 years for mining production.
- Up to two years needed for mine closure and reclamation, which comprises undoing infrastructures, safeguarding the site and restoring the site to a satisfactory level (C2D Services Inc., 2013).

While practical issues faced often largely depend on the nature and size of the mining project, a few of the key issues and risk factors for investors and stakeholders are summarised below.

6.1 Terrorism and violence

With radical groups in the region continuing to resist and attempting to undermine the current government, terrorism has been a real threat in Ethiopia and other neighbouring countries as well. While most recently, in mid-2018, it was reported that radical groups had declared a ceasefire and agreed for a peaceful resolution of differences on their secessionist demands for the Ethiopia-Somalia region and Oromia, which was the real risk of violence to personnel, damage to equipment, and conflict to affect mining projects. However, rebels in Eastern Ethiopia said that they will still demand a referendum on self-determination for the country's troubled, gas-rich Somali region during landmark peace talks with the Government held in mid-2018.

The plan by the Ogaden National Liberation Front (ONLF) may aggravate a scramble for the region's energy resources, including in the Ogaden Basin, where exports are due to begin 2021 via a pipeline to neighbouring Djibouti (Manek, 2018). Moreover, large gold deposits have been found in Oromia's Okote area and terrorist and violence activities are likely to affect commercial assets and individuals associated with the Government, which would include gold mines, such as Adola and Birbir Valley in Wollega. There is a large-scale primary gold mining operation at Lega Dembi and Sakaro, which produces about five tons of gold per annum. Recently the renewal of the private company's license was suspended due to massive protest and violence by the community in the region. Similarly, due to mass protests and violence recently practised in the region, it has been reported that the Tantalum Kenticha commercial asset was robbed and this becomes a grave concern and an ongoing issue (Reporter, 2018). The government has not been able to fix the violence happening sporadically across the country yet. This incurs risk and damage to the mining industry.

6.2 Workers' human and labour rights violations

Violations of human and labour rights of mining workers in developing countries (especially for the national and local workers) by mining companies have been a common practice, while expatriates enjoy a high salary, privileges and comfortable work conditions. Sadly, records from Africa have been frequently witnessed whereby mining companies handle local mining workers in a miserable way, perhaps close to treating them as slaves. As an example, the UN has accused a Canadian Nevsun Resources company of using forced labour at Eritrea's mine in a hard-hitting report released in 2015 (Anderson, 2015).

6.3 Inflation

Ethiopia is currently experiencing high inflation rates and Foreign Currency Crisis which are continuing to undermine growth. Inflation appears to have been caused by heavy monetary financing into the public sector. The Ethiopian Government provides guarantees, with respect to the opening of a local account in a foreign currency, retaining foreign currency earnings and remittance of profits, dividends, principal, and interest on foreign loans out of Ethiopia.

6.4 Infrastructure and access to reliable energy and power supply

Given the size of the country, infrastructure and local services are severely underdeveloped. As mineral development sites are often in remote areas, with little to no infrastructure, they are sometimes only accessible by camel or helicopter. As a result, any long-term investment in Ethiopia will require investment into road development, water access, healthcare, power generations, and general infrastructure needs.

There is a saying that "bring your own infrastructure if you would like to involve in Africa's mining industry." The perception needs to get attention and come up with a solution. The recent hydropower boom (Jembere and Yihdego, 2016; Yihdego et al., 2017) in Ethiopia could serve as an energy supplier for the mining facilities.

In the meantime, water may be a problem for the mining companies when they start operation (Yihdego et al., 2018a). As an example, 2.5 barrel of water is required to produce one barrel of shale oil.

6.5 Lack of skilled professionals

Coupled with Ethiopia's high rates of unemployment, the lack of skilled professionals in Ethiopia (such as geologists, geophysicists, geochemists, mineralogists, geotechnologists, mining engineers, land surveyors, and service providers, including up-to-date drilling rigs, robust laboratory facilities, etc.) in common with other jurisdictions is a key practical issue for investors. Moreover, the artisanal miners are poorly trained and poorly equipped. The government's mining office has been challenged due to a limited capacity and trained employees to regulate and follow up mining projects.

The greatest challenge facing the modern explorer is inadequate training and experience in processing and interpreting large datasets, as well as a limited understanding of sampling theory, geochemical associations (Yihdego and Nzikou, 2018), mineral chemistry, and the chemical processes in the primary ore forming and secondary weathering environments.

In the case of Tigray, there are a number of companies currently undertaking exploration. But most of them are suffering from lack of experts and drilling facilities, and that is preventing the booming of the industry (C2D Services Inc., 2013). There is lack of local skilled experts in metallurgy, mining engineering, laboratory technician, and, hence, mining companies resort to hiring consultants from abroad.

In Ethiopia, mine clearance is largely complete, but some elements of a holistic mine action program (namely the rehabilitation of the displaced people) were not included in the scope of either the Ethiopian Mine Action Office (EMAO) or the United Nations Development Programme (UNDP) initiative on mine action. Likewise, there is currently no capacity to handle the disposal of mobile explosive ordnance or unexploded ordnance

that can be found decades after a war ends. This is because the EMAO has been closed and the trained teams have been dismantled.

6.5.1 Regulation issues associated with lack of skilled manpower

The necessary regulation of the mining sector is weak in Ethiopia at federal, regional, and local institutional levels. It is reported a lack of skilled professionals at the federal MoMPNG and the capacity in regional governments is even weaker. Apparently, there is not a lot of expertise within the Government to properly monitor and regulate the sector. This has many consequences, among them:

a Regulations are minimal and permissive, and actual work on mining exploration license (Yihdego and Drury, 2016; Yihdego and Paffard, 2016; Yihdego, 2017) is not mandatory.

b Environmental management is poor.

c Licensing does not appear to be transparent.

d Disclosure of results is not mandatory.

e Weak institutional capacity aggravates privately-owned companies to operate with standards and objectives below required international standards (C2D Services Inc., 2013).

6.6 'Wirehousing' and 'hotelling' rule

'Wirehousing' means the deliberate fixing/holding of the mining project by an international mining company from proceeding into production. It is assumed that the mining company has obtained much detailed data and a better understanding of the resources and reserves. 'Hotelling' means setting the commodity price when the price or demand rises in the market (i.e., pricing pick at its high demand and low at its quite time). There have been cases whereby international mining companies have set a tactic to retain the project without proceeding into production, and only to return when the commodity gets into high demand that is more economically viable. Given that, the mining companies have an up-to-date resource reserve estimate before they withdraw, they will be able to come back or indirectly associate with other international companies who will take over the projects. The companies can sabotage or have an indirect influence on the company, which takes over the project via lobbying or other means. The 'wirehousing' and 'hotelling rule' may be unintentionally backed by the Ethiopian Mining Law through the provision of the Retention License.

The mining sector is the third priority in the National Growth and Transformation Plan (NGTP). In line with this, future contribution of the mining sector to growth, foreign exchange, and government's revenues are high. However, recent developments within the Ethiopian mining sector may rather induce a negative trend to the growth the government expected from the sector. Some recent examples include:

- Allana Potash (Canadian) in the Afar region was sold to an Israeli chemical company – Israel Chemicals (ICL). The news came lately, while selling of this project was in the pipeline few years ago. From the very beginning, Allana Potash was making a deal with Yara International (Norwegian) under closed door. Yara International is an

agricultural chemicals' giant company that has been supplying fertilisers to Ethiopia. Earlier on, Yara International was intending to build a potash mine in the Dallol Depression and construct a potash fertiliser factory. Also, the giant mining company BHP (Australian) left for a reason yet hardly known. Perhaps high infrastructure investment costs played a role in the decision of the foreign mining company to pull out, i.e. needing to export all the way through Djibouti. Partly, friendly economic relations with Eritrea would make the potassium mining project much more attractive. Potash is likely to be one of the first industrial minerals to contribute to the Ethiopian economic growth.

- Tullo Kapi gold/silver mine project in the Oromia region was sold by Nyota Minerals Limited (Ethiopian) to KEFI Minerals (British).

The same is true in the oil/gas sector, entertained with a continual change of ownership from one company to another for ages. Hydrocarbon exploration in Ethiopia's Ogaden Basin began over 80 years ago. The Ethiopian Government formed the Calub Gas Share Company (CGSC) to develop the fields. The Ethiopian Privatization Agency (EPA) put the CGSC up for privatisation in 1998, but the EPA, citing weak bids, withdrew the tender. In December 1999, The American Houston-based Sicor Inc. announced that it had signed a US$1.4 billion joint-venture deal to develop the Calub natural gas project. The Gas Oil Ethiopia Project (GEP), the joint-venture firm, will acquire 95% of the CGSC under the Ethiopian Government's privatisation law. The Ethiopian Government will hold a 20% interest in GEP. In December 2002, the Russian State-owned companies – Methanol and Stroytransgas were negotiating to buy 50% of the CGSC. The current oil and gas projects are relying on old known basins, that are known for many years (e.g., Ogaden Basin) – often called 'recycling the old project concept'. This becomes challenging to bring a success story and move on with tangible results (Yihdego et al., 2018a).

It looks the international mining companies are playing a game and holding the resource for the sake of shareholder/dividend sale on the global stock market (and the wirehousing is working at the expense of the people who deserve to get benefit out of this resources). The wirehousing is synonymous to the hotelling rule, applied in the oil industry to optimise exploitation patterns over time. The government does not know the real reason behind all this sabotage; let alone how to fix the problem. This seeks intervention and demands to come up with new laws, including changes in legislation and regulation alterations that will be able to rip up a contract with a mining company, if it is deemed to have unconscionable terms. A number of other aspects, in addition to those that have been discussed, can be included in a critical assessment of a licensing regime for mining. Often, this is among the unspoken topic and is deliberately chosen by the international mining companies on the assumption that they will come back again once the price of the commodity mineral (or oil and gas) rises in the world market, and/or once the infrastructure running cost gets less, as well as other factors which are not known to the client.

The basic principle used – exploiting the resource during periods when the stock value's growth rate is smaller than the capital growth rate (discount rate). From the outset, most of the mining companies have not aimed to go into production. It was not in their plan at all. They bought the land just for the sake of increasing the shareholder value in the Global Stock Market. Unless the Ethiopian MoMPNG owns a skill and establishes a right mechanism to assess and push forward the agreement and the exploration into

production – the game will continue and end up with a gross loss to the nation. The Ethiopian Growth and Transformation Plan does not seem to match and/or reconcile with the actual capability of the Ministry (mining sector). Therefore, such misunderstanding could end up with a dispute at the international court and the winner is known by default being the international mining company, who covers it up from the outset of the agreement/signatures/contractual agreement. The experience of the international mining companies exceeds far beyond the Ethiopian Government's capacity and, hence, easy to manipulate and misuse the project's agreement, without the knowledge of the host country.

The MoMPNG is given the responsibility for the proper development of the mining sector in Ethiopia. The roles of the Ministry are:

1 Mainly to generate the basic geosciences' data of the country.

2 To promote the mineral and petroleum potentials of the country.

3 To negotiate and issue licenses to the private investors.

4 To ensure that the companies conduct mineral and petroleum operations in accordance with their concession agreements.

However, there is a lack of capacity to follow up and implement the objectives mentioned above. Regarding the big companies that are doing exploration, the Tigray's regional mining bureau has neither the capacity nor the power to monitor and regulate them. The problem is dual. Firstly, the big mining companies obtained their licenses from the MoMPNG, and they will report only to that ministry; and the role of the regional bureau, more or less, is to facilitate. Secondly, a lot is to do with capacity. The bureau has no capacity at all to regulate and to manage the big companies. There is a gap between the federal and regional governments. There is only one expert at the regional level.

It is known that exploration companies that have been entitled with the licences are either the brokers or the companies that are jaggedly involved and the genuine ones. Many mining leases have been owned by rent seeker investors, who have no capacity to carry out the mining projects. They are simply an international broker, desperately looking to make profit, with no intention to develop, except to sell out (for example, the potash deposit in Ethiopia, oil and gas projects, etc.). Moreover, there is a huge gap, in terms of capacity to withstand the odds of those wrongdoings. Eventually, it is pretty difficult to know who is working in the area, being they do not want to be scrutinised, and the regulatory authority has neither the gut feeling to apply its mandatory duty nor the capacity to undertake (C2D Services Inc., 2013). This holds true at both federal and regional state levels (Tigray).

6.7 Transformation capabilities in Ethiopia awfully limited

Currently active mining projects often exclude the possibility of producing many other valuable elements that are found in the deposit; thus wasting the scarce non-renewable natural resource of the nation. In view of this, a fresh study has to take place so that necessary complementary processes be developed that would allow the co-production of other metals contained in the ores, consistent with internationally recognised environmental norms.

The MIDROC gold mine is performing a first transformation of its ore, producing a gold-silver concentrate called 'doré'. Gold artisanal miners do not transform their production that is mostly in the form of small nuggets from placer mining. It is now illegal to export raw gemstones from Ethiopia. Gemstones must receive a first transformation (which is polishing) to be exported. However, the polishing capabilities in Ethiopia are still limited. The government has recently banned exports of raw tantalum, which means that a first transformation facility will need to be built in order to resume tantalum's mining. However, no time frame has been set for the construction of processing plant, yet it is less likely that the proposed minerals' transformation industry could be attained due to the lack of infrastructure, power facilities, and access to exporting facilities. This apprehended absence of a second transformation of ore concentrates constitute a gap with the vision developed in the 2004 Ethiopian Industrial Development Strategy and other official documents, where the mining sector is seen to have the potential to be a very important trigger for industrialisation (C2D Services Inc., 2013).

6.8 Environmental impacts

Either the Federal Government or the Tigray Regional State do not have strategic environmental assessment which deals with policy of environmental programs. Indeed, there is no clear policy framework to conduct EIA. There were cases that happened to few mining sites, whereby judgement was predominantly based on political decisions. Due to negligence or ill-defined practices of implementing international standards' environmental protection conventions, treaties, and protocols, it is not only mining areas that will suffer massive environmental, social, and health impacts, but also the rivers and ecosystem in the catchment areas that will be grossly changed into dead zones and end up with an effluent sewerage of different mines.

The use of cyanide is being banned in several jurisdictions around the world, because life is more valuable than gold. This ban has been in place even in countries where strict environmental protection regulations exist. The case of Shakiso and Lega Dembi gold mining (Figure 3) in relation to cynide and mercury problems is remarkable. This presents high mercury levels in surface water of the area. The effect of mercury used for several decades in the region has had devastating health effects on the segment of population. The devastating effects of mercury are autism, learning disabilities, Alzheimer's, arthritis, depression, and bipolar disorder and other neural complications. Children and the unborn are at particular risk of health hazards. However, it would be a challenging task to comply with environmental standards, being that MIDROC company did not sign the International Cyanide Management Code. Ethiopia has no code of its own and has no reputable and independent environmental regulatory body or framework.

Many people may not know that cyanide can be used for gold extraction without hazardous effects if the processing plant is run by competent, ethical, and well-trained professionals of high integrity, and extra technical precautions are taken such as a complete destruction of the residual cyanide and neutralisation of the acid mine drainage in the mining's region. This, however, requires significant investment in wastewater treatment systems (Al-Weshah and Yihdego, 2016). Of course, since it costs money and reduces profitability, companies just get away with polluting the environment and putting people at risk. It requires competent governmental regulatory authority to enforce compliance and that is the problem, since there is no enforcement of law.

6.9 License/permit issue – case of artisanal miners

One important aspect of exploration and mining titles is that they should be exclusive. The exclusivity is important because no investor will risk capital to investigate or develop a deposit unless nobody else can legally explore or exploit ore deposits covered by the right. This principle gives the holder of the exploration license the exclusive right to explore for any minerals in the area over which the license is granted or for all minerals in a specified area. Some countries, like Ethiopia, have allowed licenses to different holders for different minerals on the same area.

It is estimated that there are some 500,000 artisanal miners in Ethiopia that produce roughly 7–8 tons of gold, 17 tons of gemstones and 140 tons of tantalite's concentrate. Artisanal mining brings around US$450 million per year. It is estimated that 5% (i.e., 5 million) of the total Ethiopian population live from the revenues generated by artisanal mining's economic activity (C2D Services Inc., 2013).

The management of the artisanal miners is in the mandate of the bureau along with following up the activities of other companies. There are around 600 artisanal mining cooperatives. They do not have enough skills, but they are doing this because it is their livelihood. There are 21 districts/woredas that cover 30% of the region, where there is a gold potential mostly located in the western Tigray – a place called Shire Enda Selassie, Hawzen, and on the border to Eritrea.

Of estimated 130,000 artisanal miners in Tigray, around 45,000 are organised in 600 cooperatives, and all of them are looking for gold (an indication that there is a gold potential in the region). They supplied 1,900 kg of gold to the National Bank of Ethiopia in 2012. There was a conflict between Ezana Mining and artisanal miners that have no license, and Ezana claimed that the area belongs to the company. The regional bureau was working with the MoMPNG to solve these issues. In the Mato Bula project there are hundreds of cooperatives of artisanal gold miners who are extracting gold. There will be community and local miners' issues which require to be solved out in a similar way though.

The implantation of a large-scale mine in a poor region with generally low school achievement will have a tremendous impact on the local population. Generally, there is no plan to prepare the local community to accommodate itself with the presence of the 'mine'. As a result, misinterpretations often occur with the artisanal miners over territory dispute, rights of way, utilisation of water and local energy, etc. In the Ethiopian context, no procedures are in place to regulate, monitor, or resolve conflicts between artisanal miners and exploration and mining companies (C2D Services Inc., 2013).

7 Role of mineral resource in development: success story from one of leading resource-based nation's economy: Australia

Despite the fact that Australia is distant and remote from the rest of the world, mining is incredibly important to the Australian economy. Australian economy is the 12th largest economy in the world, with 22 years uninterrupted growth, despite the recent past crises, which is quite remarkable. The Australian mining industry is a significant employer. Mining in Australia often occurs remote from infrastructure, port and energy with harsh environment and very unforgiving environment, where temperature exceeds 50ºC.

There are few countries which turn natural resources to substantial economy and opportunities. Australia is at the forefront. This has been done through open and business friendly economy with good regulations to give certainty for investors to invest in these major projects. A lot of discussion and updates have been carried in relation to regulation. There are other couple of elements which need to be touched, such as innovation and the fact that Australia has a very small business sector which is very important. In this regard, Australia is (Rank, 2015):

- A leading producer of bauxite/alumnium, rutile, zircon, and tantalum.
- The world's 2nd largest producer of gold, iron ore, lead, magnesium and lithium.
- The world's 3rd largest producer of nickel, uranium, and zinc.
- The world's 4th largest in coal and silver.
- The world's 5th largest in brown coal, diamond, and copper.

So Australia is a very large producer of minerals and also it has very large resources. The oil and gas industry is an emerging industry, but Australia is soon to overtake Qatar, which is the largest exporter of Liquefied Natural Gas (LNG) in the world. Australia also won the largest resource in the world, i.e. the Gorgon Gas Project which is a natural gas project in Western Australia, involving the development of the Greater Gorgon gas fields, subsea gas-gathering infrastructure, and a LNG, which is more than US$50 billion in investment. It is one of the world's largest LNG's projects and the largest single resource project in Australia's history (Chevron Australia, 2018).

In Australia the importance of diversification is not in its place. It requires not putting all your eggs in one basket. Australia is putting a lot of eggs in LNG basket, but it also gets multiple projects on multiple sites of the larger continent.

So, the contributions of the mining industry in Australia are quite important, because the mining industry is actually a very innovative sector, since most of Australian mining companies are involved and they keep very close to their customers. 80% of them work directly for the major mining companies and also work across mining cycle, and more than 50% of them work across more than one stage of that life cycle. This means that they have very strong domain knowledge, and they understand the industry with great depth. They also invest significantly in the research and development (R&D). The mining industry poses about US$4 billion a year into R&D, and Australian mining and equipment technology services companies put in US$2 billion. There is also a strong culture of innovation in the mining sector. Indeed, '3-factor index' innovation benchmark is quite a stunning name for its contribution and advances in the Australian mining industry. The 3-factor index seeks the best realistic after tax performance – with minimal increased risk – via tax optimisation, opportunistic portfolio rebalancing, low fees, and customised portfolio asset allocations informed by the research of leading investment and academic luminaries. The 3-factor index provides a sophisticated long-term portfolio management service for clients.

In addition, Australia has been the heart of the mining software industry, based in Perth, most remote city, with US$600 million and generates significant export and employ more than 2,500 people, very specialised, very niche, but very good in that space. In the same token, Wi-Fi was invented by Australian home-grown; invented by the Commonwealth Scientific and Industrial Research Organization (CSIRO), which is an independent Australian Federal Government's agency responsible for scientific research.

Wi-Fi is technology for radio wireless local areas' networking of devices and its contribution in mining industry, like other industries, is crystal clear.

The Australian mining equipment technology companies have significantly higher measure of contribution on innovation than other benchmark companies. They contributed US$90 billion to the Australian economy and employ 400,000 people. These are not the miners who got the resources, rather those who are supporting the companies that are actually taking advantage of the resources. They also got a strong bond global market (55% of their products are for export, with US$27 billion worth).

So what is the secret for the Australian mining industry being so successful? This is primarily because of the following reasons:

- It is innovative, good work, and highly skilled work force.
- The mining companies spot opportunities smartly and, hence, move into the market very quickly.
- The mining companies have deep knowledge of their customer, which they apply to actually generate growth.

Looking at the mining industry in Australia, it is actually a regional business. Australia is, somehow, pretty much a regional economy. Despite being a remote continent or far away from customers, the mining business is regional within a global perspective. 60% of Australian companies are based in regional and remote locations, and many others have headquarters in some of Australia's main cities, like Perth, which is the most remote city in the world. Those mining companies are carrying their tasks by providing quality and high paying jobs in regional communities. The average wage for the mining and mining service companies is doubled that in the retail industry (Rank, 2015).

There are also a couple of initiatives in Australia which are pretty interesting. To mention few:

- Royalty region: 25% of the royalty stream is coming from the State of Western Australia and has been re-distributed back to the regional development and communities, helping to build capacity in those communities, and to improve their services in a sustainable way. That is a return of about US$7 billion to the communities, which is quite a significant amount. That is not increasing taxes; rather it is actually taxing some of those taxes and quarantine for the community where those resources are coming from. That also allows to build modern mining cities like Pilbara (large, dry, thinly populated region in the north of Western Australia), with a new model in a mining context. Positive engagement experiment with community is something that can be readily received by developing countries, such as Ethiopia, with recent experience of Tantalum's mining site looting and disruption by community (Reporter, 2018).
- Being that the mining projects are remote with scarce population in most cases, techniques, such as 'fly in and fly out (FIFO)', have been used extensively. FIFO is a method of employing people in remote areas by flying them temporarily to the work's site instead of relocating employees and their families.
- There is a challenge that many people initially consider the 'smoothing out the booms and busts' in Australia mining is intractable, being that it is a central discussion point. Of course, Australia cannot control the global metal markets, and in

a democratic economic system it is not conceivable that Australians would. However, that does not mean Australians cannot enhance and optimise the way people are impacted by those external commodity cycles. Geoscientists specialise in providing new insights and approaches; dealing with large, complex, fuzzy's problems. This is the science that deals with deep time (from now back to the origin of Earth 4.6 billion years ago), huge-scale difference (from crystalline processes to plate tectonics), and physical extremes (high temperature and/or high pressure, to aquatic and atmospheric conditions).

- With the emerging technologies, Australians all are excited about, and Australian miners are among the most innovative in the world. Time and again Australians have developed software packages that break new boundaries, and Australians have effectively spread their influence rapidly everywhere that their professionals go. The early hype around big data is now settling down, but robotics and remote control systems will provide safe work for many people for many years to come as the mining industry modernises. A manufacturing approach to commodity production is developing in large iron, copper, and coal mining companies. This will trickle down into medium size companies as the support industries mature and start to provide their services to the smaller players. One of the bid drivers is when there is a change from cost minimisation to production optimisation (that is getting the grade up instead of the unit costs down) (Shaw, 2018).

7.1 Sustainable development in mining industry: Australia's perspective

Environment co-existing with community is very important. Australia is at the forefront in the sustainable mining research and has got mining companies very strong in doing that particularly when applied to mineral and mining sector. Besides to proven Australia's drought proof/resilience economy (Yihdego et al., 2018b), there is an immense capacity in environmental and social impacts' assessment, how to manage these impacts and social and environmental aspects of temporary work forces during the build/operate and down face/underground. Moreover, there is a community engagement, i.e., social license to operate which is increasingly critical. Finally, rehabilitation, planning, implementing landforms, design, top-soil usage, and re-vegetation are really important things to make sure that those mining sites are returned back to the community in a good state. So the mining sector in Australia is:

- Delivering and building mining in regional locations, creating jobs in regions.
- Providing great innovation.
- Providing a real driver to nation's economy, which is a huge space difference to the economy.

To wrap up, having resources is not enough, but it literally demands a robust mining industry that goes with it. Australia has built big and unclean processing plants. In the meantime, Australia is actually building a service industry at the back of the mining sector and that signifies the strength of the mining sector and why it has been so successful, very smart and efficient.

8 Improving the Ethiopian mining industry, including based on lessons from Australia

The mining sector remains one of the priority sectors for many countries around the world, with main strategic directions of attracting sizable FDI for exploration and extraction of minerals, increase foreign exchange earnings of the sector and focus on production of mineral inputs for the manufacturing sector that promotes import substitution. Mining operations within the Ethiopian regional states are expected to be an important economic catalyst for the Ethiopian Government's export-orientated development strategy (JICA, 2007, 2008). Recognising the need to promote market-oriented modern mineral production, the regional government has set a plan to bring the minerals' sector to a significant gross domestic product (GDP) contribution in the coming years.

Efforts need to be made that contribute to different themes of mining and minerals sustainability such as: community, operational challenges and opportunities, environment, finance and case studies, and models and frameworks. The Ethiopian Government should aim to explore the relationships between these themes and their potential conflicts due to the different perspectives of multiple stakeholders, while retaining a fundamental view on the effective implementation of sustainability in mining and minerals' industry.

8.1 Strengthen the human capital in Ethiopia through technical training and collaboration engagement

Employment opportunities in the future will be significantly different from those of the past and educational pathways need to provide for this. Geoscience graduates should have highly transferable generic skills that extend beyond traditional geoscience careers. Working alongside the Ethiopian Government's led efforts to train and develop specialists is a key capacity's building factor for any project of this nature (Yihdego and Kwadwo, 2017). The Tigray National Regional Government (TNRG) should consider restructuring the mining sectors and affiliated ones that suit for the best mining industry success and overall economic growth in line with the overall policy and expectations.

The technical capacity pit falls can be filled up as follows:

a By supporting technical training: through collaboration with local and international research and mining companies to create a critical mass. This centre should also offer training related to maintenance. To absorb the cost of such a centre it will be important to solicit the implication of the mining companies. In the future, this centre should have antennas in regions where the mining activities are intensifying.

b By developing critical skills among stakeholders: with continuing education approach, it should be useful to offer courses, workshops, distance or presence conference to develop awareness about some issues related to the mining sector and to promote integrated view among stakeholders. For examples, it can be offered leadership skills training, functional seminars related to negotiations with mining companies, gender awareness, environmental protection, respect of human rights, etc. As an example, an artesian miner's cooperative from Tigray which consists of 3 to 25 members, has 30% efficiency implying 70% of the gold is said to be wastage.

In line with this, Tigray mining bureau supported by the World Bank (World Bank, 2016), was training artisanal miners on creating skills, on how to mine, how to save money and how to prepare proposals to commence other businesses. The idea is to transfer the artisanal miners into other business streams, equip them with necessary skills required to establish and run a small-scale mining company (C2D Services Inc., 2013).

c By supporting the sharing of knowledge and best practices (e.g., mine to mill): systematic evaluation of projects or programs and public diffusion of the result, organisation of seminars on that thematic. Importance should be given here on environment and gender issues. As a mining professional of a significant knowledge and awareness regarding mining related issues, the Tigray Regional State should exert to have an educated, trained and an accomplished scientist in the field, who is readily capable to research, study, develop, and design minerals and metals processing plants.

d By offering tailored training to the artisanal miners: contribute to development of a curriculum adapted to this sector of the mining industry. They can also be assisted in the regrouping of artisanal miners in cooperatives or small-scale enterprises (Sonobe et al., 2011). Ultimately, community's engagement through mining corporate sustainability can be attained via communication, mining best practices, winning perceptions, robust regulatory tools, strong corporate community partnerships, rigorous license scrutiny to operate, interaction between minerals/systems/people/other elements, education/training, multi-stakeholder perspectives, and collaborations. In line with this, the Tigray region has got gemstone (precious Sapphire), which needs value added mining strategy and plausible artisanal mining policy (to improve the traditional artisanal mining widely practised).

e Institutional collaboration. Whereas institutional collaboration in research has many obvious advantages, the benefits of collaboration on the teaching front are less clear. The Victorian Institute of Earth and Planetary Sciences, Australia (a teaching collaboration between Monash and Melbourne) has been in place for two decades, the equivalent Sydney Universities Consortium of Geology and Geophysics (Universities of Sydney, NSW, Macquarie and UTS) was shorter-lived, though some common field-based modules remain. Whereas such agreements were designed to provide students wider selection of subjects in their upper undergraduate years (Ausimmbulletin, 2017; Cohen, 2017). Indeed, such collaboration between the Ethiopian and Australian Governments can be readily implemented among the universities (namely Adigrat, Axum, Mekelle, and Raya) found in Tigray together with other universities in the country.

8.1.1 Technological advances

Changes in systems are brought about by revolution or evolution. At the tertiary level, changes to the way universities deliver academic programs are becoming more revolutionary than evolutionary. There are several drivers for this revolution. The dominant drivers are the dramatic and disruptive advances in the digital world – from data availability and advanced personal digital devices to new capabilities in data

analytics (Bain, 2004; Hochella, 2007). Advances in the quality and quantity of online material and the capacity for software to analyse students' performance will benefit students at one end of the scale, and potentially allow universities to significantly 'scale up' teaching at the other end. Some in industry criticise universities for not turning out 'work-ready' graduates. The AusIMM provides an excellent blueprint for graduate programs (AusIMM, 2017) but few companies or governmental agencies have the resources to properly implement them. In the case of the geosciences, the AusIMM program is very mine-site oriented, though the model is adaptable to suit employment circumstances. If geoscience education in Australia is critical to national development of the country, then it should be approached on a national basis through the collaborative efforts of government, education's providers and industry (Cohen, 2017; GSA, 2016; Ronald, 2017; Thompson, 2016; Thompson et al., 2016).

Significant advances have been made in airborne, ground and wireline geophysical acquisition, as well as in data processing techniques. Technology still relies on professional skills. The innovations in airborne methods are particularly relevant to exploration in Africa, because of the improved depth penetration through conductive cover. The airborne methods cover a range of techniques, such as magnetics, electromagnetics, radiometrics, gravity gradiometry, and georadar, some of which can be applied simultaneously. There have even been advances in an airborne induced polarisation (IP) system, a method that has traditionally required ground contact (Theart et al., 2018).

Data processing methods have improved significantly, enabling the reprocessing of legacy data using new interpretation and modelling techniques. There has been enormous development in the ability to collect and process information. The sensitivity and efficiency of geochemical and geophysical tools has been greatly improved, leading to lower detection limits with reduced measurement times; these tools have also become much smaller and more user-friendly. In addition, remote sensing, GIS, and satellite methodologies now provide accurate geo-spatial location and multispectral coverage that can be integrated with geological, tectonic, geophysical, and geochemical information (Yihdego et al., 2015).

For geochemistry, the biggest advances in field equipment have been continuing improvements in the portable X-ray fluorescence (XRF) for chemical analysis, and in infra-red and near infra-red spectrometry, as well as X-ray diffraction tools, for mineral identification and quantification. If used responsibly, such instruments can dramatically reduce turn-around time on sample analyses, rapid redirection of sampling programs, target selection and follow-up exploration (Theart et al., 2018).

Joint inversions of previously disparate datasets are now possible – for example, with gravity and seismic arrival time data – resulting in an improvement in resolution, better constrained models and reduced uncertainties (Theart et al., 2018). Therefore, Tigray minerals (such as base metals, precious metals, industrial metals, including graphite) and oil/gas resources needs to be re-assessed using up-to-date technologies, skills, innovation, and science. As an example, investigations of the graphite often comprises mapping the graphite body by geological and geophysical methods (with up-to-date methods mentioned above), analysis of the graphite carbon content, and determination of the size and texture of the graphite grains. Graphite occurrences in the other part of Ethiopia are hosted by quartzite, quartz-feldspar-mica schist and rarely by amphibole schist, which are

abundant in Tigray. Pegmatitic graphite bodies rarely occur discordant to the main schistosity.

8.2 Underpin the evidence and transparency-regulation

Regulatory transparency can be enriched by:

a Reinforcing the mechanism of accountability and transparency in the federal, regional, and local institutions.

b Supporting the implementation of database, network, infrastructure, and application. These systems should be found in universities and institutions involved in mining development.

c Reinforcing the diversification potential of the mining sector: that requires a good identification of promising niche where Ethiopian industries can supply and offer services to the mining sector. Maintenance, construction, transportation and procurement activities can be of premier importance here.

d Collaborating and supporting the creation of links and networks with foreign expertise. The universities should beneficiate from that kind of intervention and reinforcement, especially to build a stronger professional staff.

The Ethiopian Government is expected to seek adding significant commercial value to the resources by exploiting the operations' by-products in a clear and transparent way. Mining companies and their selected partner(s) are expected to have collectively the following:

1 The technical and financial resources to review and undertake due diligence, feasibility, and engineering, procurement and construction management to best practice standards and implement best practice operations to maximise resource exploitation. With regard to efforts by third parties (such as a downstream especially metals processor) to bid the rights to operate and expand mineral resources, an obvious challenge for an incoming bidder will be to demonstrate the financial and technical capacity and credibility, to outweigh residual negative attitudes of the Government due to past failures. Such an organisation should be ready to conceive a practical and economic approach.

2 Total capability, or create access to, viable long-term partners for off-take of the minerals (such as precious metals, base metals, gemstone, niobium, lithium, and other by-products) as well as oil shale. Diplomatic channels are important to consolidate international partnership and gain wealthy of knowledge, and technology experiences from oil shale producing countries, such as Estonia, Brazil, and Jordan (Yihdego et al., 2018a).

3 Technical resources, in conjunction with the technical resources of Ethiopia and its Government, and financial resources for the construction and operation of the mining activities, processing and infrastructure to sustain full-scale mining, processing, and off-take export operations.

The Ethiopian Extractive Industries Transparency Initiative Chapter has become one of the members of the global Extractive Industries Transparency Initiative (EITI). The

global EITI has a robust standards and requirements for annual audit and, hence, can serve as an instrumental tool to advocate (and bring compensatory justices) for damages and any irresponsible mining exploitations in the country.

In federally governed countries the Federal Government normally receives 15% to 20% of the profit generated by mining companies, whereas the regional government gets 10% to 15% of the profit. In the case of Ethiopia, the Ethiopian Government gives merely 2% to mining area, which is fairly small. How much of the profit the Regional Government is to receive is what matters most? The 2% could be subject to debate and argument, and would be good to get the deal right for the benefit of the local community.

8.3 Support the institutional capacity

Institutional strength can be attained by:

a Enhancing the institutional strength and capability will keep the finger on the pulse of mining locally and regionally, which would agree the sentiment to be upbeat, supported by an increase in transactions and capital raisings over the coming years. The support could be backed up via finance, sustainability mining accounting, and reporting in developing countries, ethical and green investment, energy and resource accounting/auditing, mineral economics, business systems, law, regulation, and taxation.

b Reinforcing and supporting the federal, regional, and local institutions. This can be done through organisational design, strategic thinking, risk analysis studies, economical studies, legislative framework, structuration of R&D activities, target training, and coaching to the junior and to the senior professionals.

c Upgrading the facilities and installations in higher education institution. This requires equipment of laboratories, purchase of other specialised equipment, creation of resources centres, mutualisation of expensive resources among education, and training institutions. The priority here should be given to the geosciences departments.

d Developing a culture of values and ethics among stakeholders. This requires creation of values' and ethics' chart for mining development, training of the stakeholders on that topic, and tracking the result on this issue (C2D Services Inc., 2013).

The scale of this strategy is likely a long-term one and the components of the strategy can be further refined at mining project design level.

8.3.1 Regulation improvement

Many countries, such as Mongolia, have been struggling with their regulation laws. The Mongolian authorities, for instance, have already undertaken to liberalise the mining law, but highlighting the importance of finishing the task and specifically capturing the critical role of the competent engineer in resource estimation. This includes refining the reserve estimate and making it available to the public, besides to encouraging new discovery using all means of explorations, such as drone, etc. Value-added concepts are also among the list of areas which need to get improved.

Currently, mining activities are, by and large expected to take place in accordance with the Mining Operations Proclamation number 678/2010. This proclamation, unlike many other economic laws of Ethiopia, has paid good attention to environmental protection. For instance, it requires everyone to conduct mining operations in a manner that complies with environmental protection laws of the country [Article 34(1)(b)]. One of the environmental protection laws referred to in here is the Environmental Pollution Control Proclamation No. 300/2002, which prohibits any person from polluting the environment or causing others to pollute the environment [Article 3(1)]. So, miners should not engage in mining activities by endangering the environment (and the people as part thereof).

Moreover, the Mining Operations Proclamation requires EIA to be conducted to issue license for projects like that of MIDROC (Article 70). The same is true for renewal of licenses (see, e.g., Article 27 for large-scale mining license renewal). Well, perhaps, MIDROC might have obtained its license before the Environmental Impact Assessment. Proclamation No. 299/2002 was enacted but this Proclamation, together with the Mining Operations Proclamation, can apply to MIDROC now during license renewal. So, was EIA conducted before its license was renewed? Were the EIA procedures duly followed in the process like involving the public in the assessment? On the other hand, whether there is/was EIA or not, pursuant to the Mining Operations Proclamation, if any mining operation poses imminent danger to the environment, then licenses can be suspended or even revoked by the concerned licensing authority (Article 44), regardless of how much money has been spent by the miner/licensee.

In the worst-case scenario, if a licensee violates the provisions of the Mining Operations Proclamation, such as those relating to environmental protection, then there will be a criminal liability of a fine or an imprisonment or both (Article 78). So, if there is willingness, there is surely a way to hold anyone responsible both civilly and criminally for their wrong-doings. According to Article 44(1) of the FDRE constitution, all persons have the right to live in clean and healthy environment. In addition to this, Article 92(1) of the same constitution obliges the government to make all necessary endeavours to ensure that the environment be clean and healthy for the life of the whole community.

The proclamation states preferential duty and tax provisions on equipment and machinery, a 5%–8% production royalty (revised in Proclamation 678/2010), a 35% income tax (intended future plan of reducing mining corporate tax from 35% to 25%, with breaks and holidays), on taxable income, and a structuring to allow for repatriation of profits. These incomes should be published officially and used transparently. Therefore, the wealth that can be generated from the mineral and petroleum resources will never be accursed, rather a blessing for the development of the country. Much foreign and some local companies have been granted reconnaissance, and exploration and mining licenses for gold and base metals, cement and ceramic raw materials, potash, diatomite, and other industrial and construction materials.

8.3.1.1 License renewal requirement from the perspective of regulatory body

The mining development in Tigray Regional State should intensify over the days to come and there is room for supporting this development in a way that maximises the economic and social benefits for the country, based on the nature of identifying strategic gaps through regulatory and social processes. This will greatly assist in identifying the demands of the mining operators, the educational/training system, and the gap that

hinders the development of the mining sector. This analysis will lead to the formulation of a strategy based on the reinforcement of the regulatory and social processes involved in mining development.

A number of other aspects, in addition to those that have been discussed, can be included in a critical assessment of a licensing regime for mining. These include:

1 The right to mine must be immune to discretionary decision-making by the authorities, that is, the conditions under.

2 What can be taken away must be clearly defined and must not be seen as arbitrary.

3 The conditions for granting a right must be equal for all.

4 The right must be transferable.

The Ethiopian Government should seek lessons from mining license scrutiny, with respect to approval and renewal from the other part of the world. As an example, the giant leading mining company – BHP – has settled in for another 100 years of Pilbara iron ore. The Western Australia's Environmental Protection Authority has given mining giant – BHP – a license to operate in the Pilbara for the next 100 years, with the approval of the Big Australian's strategic mining proposal (AMM, 2018). A lot of experience and skills needs to be sought after to bring it to the local knowledge.

The Regional Government of Tigray should aim to acquire a capacity with a long-term license approval for such giant mining companies. License renewal conditions should be in place, to mention a few:

a The production has to be suspended until the mess created to-date is cleaned up and the area is fully rehabilitated (Yihdego, 2016b; Yihdego and Al-Weshah, 2016). This has to be a pre-condition for the resumption of production.

b The process has to be audited for compliance with internationally accepted norms. If not, a technical remedy has to be put in place before the resumption of normal operation.

c All sources of drinking water in the region have to be tested and monitored to make sure they are safe for consumption by humans, animals, and plants (Yihdego, 2017).

d Alternatively, the population has to be relocated with compensation to safer locations.

e The population suffering from the consequences of the company's negligent operations has to be compensated, and free medical assistance be given to the life-long victims.

f Tigray Regional State should determine how much it would cost for the closure of the mine and rehabilitation of the land upon completion of the ore production. This money has to be deposited in a bank in instalments over the life of the mine. It is the responsibility of the company to close the mine and rehabilitate the land in internationally accepted norms before it is allowed to leave the operation or declare bankruptcy. At the end of the mine's life, the company has the choice of properly closing the mine and get the deposit back, or the government will use the money to do the closure itself.

g The Regional State Government has the right and the obligation to demand that these and other conditions are met for the ore's production to resume.

h Consequently, the regional state could and should re-possess the property and open it for investment to restore political, economic, and social justice.

Furthermore, the Tigray Regional State has to setup a mining intelligence jointly with the MoMPNG (Federal) to assess the profile and capacity of international mining companies, before awarding the bid/selection process. Many of the mining companies lack capacity and are not genuine to carry out the task, and their historical profile has bad reputation or little experience to prove. Such approach saves from disputes/court cases and loss of time. As the matter of fact, most of the time the court case ends up in favour of the international mining companies, because they outsmart the government's capacity and are good enough to cover up for any eventuality in their contractual agreement, before starting the work.

Society is looking forward to have Tigray with a fair jurisdiction with an improved governmental policy. Tigray will have bold aspirations for what has been witnessed a nascent mining industry in Australia and to build on the success of mineral resources. Implementing a competitive and stable administrative and fiscal regime attracts to seeking to directly engage with mining companies and attracts investment.

Concerning the activities of the artisanal miners and the potential damage they cause on the environment, there is agreement between the cooperatives and the bureau to do rehabilitation work through a corresponding rate of reasonable compensation. In the Mato Bula project, Tigray, there are hundreds of cooperatives of artisanal gold miners who are extracting gold. Therefore, efforts should be made to establish these local miners before developing this resource, which includes agreement to compensate the local people and the environment.

8.4 Sustainable mining perspective

8.4.1 Environmental aspects

For any project, it is mandatory to do EIA and to find solutions for the ensuing impacts. These are really good alternative suggested solutions. But there is no history of development with zero pollution. Environmental pollution mitigation's policy of the country should be improved to the maximum possible level.

Sustainability has multiple dimensions and that a single approach to achieving mining sustainability is not a good choice (Yihdego and Salem, 2017). Instead, the perspectives of multiple stakeholders, including industry personnel, politicians, and environmentalists, need to be considered. Achieving sustainable development in mining and minerals seeks to offer a critical examination of many different perspectives, as well as disciplinary approaches to sustainable development in the mining and mineral sectors. The Tigray Regional State needs to explore how specific solutions may be produced in order to address the sustainability challenges that currently exist (Yihdego and Salem, 2017).

Despite tremendous growth in the mining and minerals sectors globally, those industries continue to face serious allegations in terms of their sustainability and industry practices. Both industrial sectors, mining and minerals are often pejoratively categorised as being '3D' – dirty, dangerous, and difficult, because of the inherent challenges in maintaining sustainability. In response, stakeholders, such as the International Council on

Mining and Metals, have begun to examine the topics of sustainability in these sectors by introducing new frameworks, a prominent example of which is the renowned Sustainable Development Framework and Community Development Toolkit. Although new strategies and concepts to improve sustainability practices are being introduced to the research realm, few succeed in providing fruitful sustainable advantages. Instead, the majority of studies focus on the social impacts of mining and minerals. Local communities pressure mining and mineral sector stakeholders to focus on the license to operate rather than on economic advantages.

Alternative processes that do not require the use of cyanide or enormously reduce the amount have to be developed. If alternative processes cannot be found, then the current process has to undergo vigorous review and overhaul to include processing steps that enable zero cyanide discharge and most of all introduce processing steps that allow the recovery of additional resources (valuable metals) that are currently ignored and discarded. Shakiso (a town in southern Ethiopia) is not only about gold, but there are more valuable metals than people think there are. It is the solemn duty of scientists, engineers, environmentalists, lawyers, activists and the Regional Government to advocate for the maximisation of the extraction of this vast non-renewable resource in a manner that is ethical, environmentally safe, and socially just.

Except for reconnaissance, exploration, retention and artisanal mining licenses, applicants for a license are required to submit an EIA and obtain approval from the competent authority. They are also required to allocate funds for rehabilitation of environmental impact, and participate in community development plans within the license area. For mining industry in Ethiopia and anywhere else, an EIA should be undertaken before the mining starts and before license is issued. And during the exploration and mining operations, air, soil, and water quality testing and assessments (Yihdego and Al-Weshah, 2016), environmental monitoring and protection activities, and development of and compliance with land rehabilitation targets should be periodically undertaken. However, it has been witnessed that capacities of the Ethiopian mining sector (Federal and Regional) are in shortfall to regulate environmental impacts.

Cyanide is a poison but beyond that the leaching of the heavy metals, such as lead and mercury, is very dangerous, and it needs immediate attention. Globally, mining companies are facing increasingly tough regulations that prevent or restrict the use of cyanide due to environmental and health concerns. Several regional agencies in the USA, South America, and Europe have banned the use of cyanide for gold extraction, which is globally known as 'Gold Cyanidation Ban'. An example is the extraction and production of gold, using a non-toxic chemical process free of cyanide and mercury use. Introducing such recent technology will be a game-changer for small gold producers (may also be applied to other minerals such as silver and copper) or those looking to get ahead of increasing market demand for greener commodities (Australian Mining, 2018).

Conventional gold processes rely on cyanidation. In many countries (including Ethiopia), there are several environmental and economic challenges with processing gold using the conventional 'cyanidation' technique that has left known gold deposits stranded. Around the world, governmental regulations are becoming increasingly stringent on use of cyanide in gold processing. It has already been banned or restricted in several Australian states and territories, including Victoria and the northern territory, as well as some US states.

Cost-effective gold recovery alternatives are needed to address barriers to entry for small producers and new governmental regulations (CSIRO, 2018). A cheaper, safer cyanide-free process of gold extraction has been demonstrated at a pilot plant in Western Australia operated by CSIRO in partnership with Eco Minerals Research. The new technology offers the possibility of smaller producers entering the market competitively, especially in countries such as Ethiopia, where improving environmental regulations are restricting the use of cyanide, due to environmental and health concerns. The cyanide-free process has the added benefit of removing mercury from the equation too (CSIRO, 2018).

The cost-effective and cyanide-free gold recovery process 'going for gold' is being demonstrated in partnership with industry. The solution provides a safe, environmentally-friendly alternative to conventional processes and could help turn many of Australia's stranded gold deposits into production (CSIRO, 2018). The Tigray Regional State needs to introduce and consider the newly innovation explained above. With an innovation example described here from Australia's partnering with industry to demonstrate the solution at scale; meaning cyanide and mercury free gold. The Mato Bula project is a gold bearing pyrite concentrate and will be produced and treated off-site by Carbon in Leach (CIL) technology. The Mato Bula and the Tigray area mineral conditions are superb to apply other non-cyanide related processes.

Up to now, the generous natural resource nature bestowed in Africa has been a curse, and for sure not a blessing. As a nation, as people of good conscience, it is needed to show some humanity and put life before greed this time. As with all mining projects, a sustainable and successful project is in part dependent upon the degree of engagement with the local community and the government (federal and regional), as cooperation and communication can be key mitigating factors against the risks and practical issues. Although Ethiopia may face these practical issues, they are certainly not rare in the African context. It is well publicised that investors are aware of the country's mineral-rich landscape. Therefore, with the continued efforts of the Ethiopian Government to utilise its newly established mining legislation to assist in mitigating the practical issues faced by investors, it is a country to be closely monitored for its surplus of investment opportunities.

From the environment perspective, the mining strategy should focus on operational challenges and opportunities, sustainable challenges in underground mining, industrial ecology, sustainable supply chain and operations management in mining, rebound dynamic risk assessment, health and safety, information technologies, engineering solutions. Furthermore, related subjects such as carbon foot prints and ethical culture for oil and gas, mining industries, landfill management, mine drainage, water accounting are among the lists to consider.

8.4.2 New discovery, innovation, and advancement

There has been no new discovery for exploration prospect, and this will question the sustainability of mining. The Ethiopian Government has to inject money and support innovation together with the stakeholders (industry academia, etc.). It should be remembered that the easy mineral targets have already been found. This makes the new advances discussed here hugely significant, if they are coupled with advanced exploration and data processing methods (Yihdego, 2016a). In fact, some of the historical statistical methods used need to be 're-discovered'.

There are a number of reasons why Ethiopia (and Africa in general) still has extensive exploration potential. These include the thick cover from deep weathering during the Mesozoic, with relatively minor denudation since then. Also, there is extensive cover formed by Cenozoic sediments, and the relatively hostile environments in the equatorial forest of central Africa and the desert areas of the continent have impeded exploration efforts (Theart et al., 2018). There are modern hyperspectral methods that may be used in the indicator mineral identification and quantification in airborne (including drone), soil, and core and chip sample applications. Exploration geochemistry is at a new dawn, and the role of the well-qualified, experienced geochemist is becoming ever more important (Theart et al., 2018).

The Tigray Regional Government (represented in the Mining and Energy Bureau) has not yet made adequate assessment to discover and locate the reserve of the precious gemstone, sapphire, but there will be plans to commission studies to large-scale miners for the discovery of the regions' deposits of this gemstone. Before promoting these minerals and going to the global market, The Tigray Regional Government should conduct a geological survey to discover the state reserve of the mineral, and should also conduct laboratory tests to demonstrate the nature of the mineral, including grades and quality (North Miner, 2012). So far, the Tigray Regional Government has no transparency concerning figures and facts over gemstone (C2D Services Inc., 2013).

The northern and western regions of Ethiopia exploration licenses lie within the southern extension of the metal-rich Nubian-Arabian Greenstone belt. Over 60 massive sulphide zones, including Bisha deposit (copper, zinc, gold, and silver), and Emba Derho and Debarwa projects (copper, zinc, and gold), Eritrea located north of the Tigray Regional State and several gold deposits have been discovered in these greenstone belts.

Ethiopia's current proven hydrocarbon reserves are minimal, but the potential to increase reserves to commercial viability is seen as promising. The country's geology is similar to that of its oil-producing and precious metals neighbouring countries to the east (on the Arabian Peninsula) and the north (Eritrea). Ethiopia's sedimentary basins are located between old and recent discovery areas in the Middle East, the Eastern African Rift System, and the Sudan and South Sudan basins. Sedimentary basins cover more than 30% of Ethiopia (Figure 2) and the known basins include: the Ogaden Basin, Abay/Blue Nile Basin, Gambela Basin, Mekelle Basin (Tigray, Figure 4), Southern Ethiopia Basin, and Metema Basin. The Ogaden Basin has proved petroleum potential. Reservoir rocks are mainly Permian to Lower Jurassic sandstones (the Calub and Adigrat Formations), and Callovian limestones. Recently a new petroleum system has been identified at the Bokh Shale-Gumburo sandstone. Detail exploration in relation to petroleum geology of the Mekelle Basin is expected in view of the recent discovery and besides to the oil shale deposit (Yihdego et al., 2018a).

A massive deposit of sapphire has been found in the Tigray State, northern Ethiopia. According to the Tigray Regional State official of mining and energy sector, the sapphire is sold at 2,500 to 3,500 Ethiopia local currency (Birr) per gram in local markets, which is equivalent to approximately US$90–125 (as for October 2018). In the world market a finished product of a blue sapphire will be sold at price of up to US$15,000.00 per carat (TOL, 2017). However, the government should exert effort for the gemstone to be sold as an Ethiopian sapphire in the world market, because some companies are marketing it as a Madagascar's sapphire in the world and the Ethiopian Government wants to stop that (TOL, 2017).

The Tigray Regional Government should devise a plan to partner with small and large companies, governments, and industry around the world. There are various Chinese companies engaged in mineral exploration and development projects in Ethiopia. The Chinese Geological Survey (CGS) has been jointly undertaking geophysical studies with the EGS in southwest Ethiopia. The Chinese Government funded the project while the CGS provided experts and equipment. The joint study between CGS and EGS has identified various minerals deposits including gold, silver, copper, and iron in the western part of Ethiopia. Southwest Ethiopia is known for rich mineral resources. Particularly Wollega and Benishangul are the regions endowed with gold and other base metal deposits.

The new gold (and base metals – zinc, silver, and lead) discoveries in Werri of Tigray (located in central Tigray) were expected to start production in three years. However, this has not been happening yet. This needs to get initiation by the Regional Government and expedite the exploration process at the soonest possible time (Mining, 2012). Over 60 massive sulphide zones, including Nevsun's Bisha deposit, Eritrea (immediate north of Tigray), and several gold deposits have been discovered in these greenstone belts. Further discovery in line with this is highly recommended. The government needs to revise this and think out of the box. Just to mention a few, there are alternatives to carry out the exploration in different perspectives, such as:

1 Old basin with new thinking of exploration/innovations.

2 New basin with old thinking of exploration methods.

3 New basin with up-to-date technology and cutting edge innovations' approaches.

On the other hand, exploring technical and commercial viability of constructing pumped hydroelectric storage as the future for old mines is gaining momentum in recent years. Energy storage is becoming increasingly important as more renewables are connected to electricity grids. Pumped hydro storage can provide a cost-effective alternative to large-scale battery storage and concentrating solar thermal storage. The MoMPNG and the Tigray Regional Government should plan to identify the technical, financial, and regulatory roadblocks to the further development of pumped hydro and large-scale storage, along with any risks involved with using disused or abandoned mine sites for energy storage (Utility Magazine, 2016).

In summary, the Tigray Regional Government should address the crucial issues mentioned and formulate a policy that relates to the contribution of mineral wealth in the social and economic prosperity of the country. Smart mining, digitisation in equipments, technology and industry mining contributions to regional development will benefit the local societies, neighbouring the mining sites.

9 Discussion and conclusions

Ethiopia is the oldest independent country in Africa, with an economy mostly based on agriculture, and it is among the fastest growing economies in the world. The International Monetary Fund (IMF) estimates that Ethiopia will have an average GDP growth rate of 7.4% from 2017 to 2020. In early 2011, the Economist magazine predicted Ethiopia will have the third highest growth rate in the world over the next five years, after China and India. Ethiopia is a mining-friendly jurisdiction, working under the Mining Operations

Proclamation since 2010, with several gold, copper, and potash projects in operation and under development.

The Ethiopian mining key facts can be summarised as follows:

1 25% corporate tax rate, with breaks and holidays

2 royalty at discretion of the MoMPNG

3 customs and duties exemptions available on equipment, machinery, vehicles, and spare parts required for mineral operations

4 carry forward of losses up to ten years.

Indeed, the challenges to the Ethiopian mining industry include: terrorism, inflation, infrastructure, lack of skilled professionals, 'wirehousing and hotelling', access to reliable energy and power supply to the mining projects, protection of workers' labour and human rights, protection of the environment and public health, and the limitations of transformation capabilities.

There have been dozens of mining companies which have shown up in the Ethiopian mining (including oil/gas) and exploration for the last two decades, but left with nil success story to the nation. Even the Ethiopian Government does not know the real reason behind all this sabotage, let alone to correct the problem up-until this day. On the flipside, mining companies are continually facing disputes that severely affect the nation's economic benefit through massive work delays which attract huge conflicts management costs, damages to the reputation of the mining industry, and eventually signals investor uncertainty. Therefore, the Ethiopian Government should have the right mechanism, and should possess globally skilled manpower to identify, diagnose, and adjust all such foreseeable future problems with international mining experts and intelligence.

The Ethiopian Government has not been successful to comprehend the problems and address the issues of concern for the last two decades, even-though the resources sector is recently considered in the list of priorities in the coming five years' term. The sector is expected to gain revenue and back up development and employment opportunities, etc., but they all look nowhere except into the 'black hole'. The Ethiopian Government needs to introduce new methods that will be able to rip-up a contract with the mining companies if the government is deemed to have unconscionable terms.

A number of other aspects, in addition to those that have been discussed, can be included in a critical assessment of a licensing regime for mining. The Ethiopian Legislation fairly meets all these requirements and there is no reason to go further into a review of the exact modalities of all the provisions. The rights to explore and to mine are at the centre of the mining policy and it is the way that the government chooses to design the appropriate systems for allocating and defining rights that account largely for how a country is viewed by potential investors (Cimoli et al., 2009; Shimada, 2009).

The stakeholders need to consider that there will be lots of leading works and at-most efforts to connecting critical raw materials with future societal demands. The role of technology in enhancing sustainable outcome is indispensable through active engagement of home-grown Tigray (Ethiopia) cultural collaboration. The Tigray Regional Government needs to prepare a current status of the mining industry detail and make publicly available as part of how to improve mining investment opportunities:

1 overview of mining sector
2 brief review of ongoing mining projects
3 investment opportunities, including funded projects in the resources' sector
4 market's entry licensing and regulatory criteria for new investors
5 next steps for investors.

Bright future is ahead for the Tigray Regional State because of its proximity to portal access due to recent peace deal agreement reached with Eritrea and, hence, the security and investment risk gets at ease. Moreover, the existing success story from the Eritrea mining projects which share the same geology and resources with Tigray will benefit to scale up and apply the already gathered information as a big advantage. The government (federal and regional) should prioritise societal demand and project commodity market.

This paper emphasises challenges on large-scale mining of minerals and oil and gas, namely precious metals (such as gold, silver and platinum), base metals (such as iron and nickel) and highly priced minerals. Developments in Tigray will continue to unfold, provided the government is committed to issue a standardised integrity pledge as part of its attempt to rationalise the local content provisions within the country. This will help to reduce a little uncertainty. The need to learn more about new export markets is becoming more imperative as competition for business opportunities in local markets grows tougher. This paper does not attempt to provide precise recommendations for legal texts but only to sketch options that can be the subject of discussion.

The assessment presented in this study will greatly benefit to evaluate relevant topics, including:

1 Where the mining and mineral industry stands in relation to the national and regional strategies?
2 What are the key challenges in developing mining projects, with respect to the investor's viewpoint?
3 What are the mineral resources potential and benefits for economic growth (best international practices)?
4 What are the responsibilities of the mining industry and the best research practices?
5 How to improve the mining industry through financing projects and enabling legal and taxation framework?
6 Regarding the mining and sustainable development, can Tigray, in particular, and Ethiopia, in general, make a step further?
7 Can the mining industry in Ethiopia address important issues, such as workers' safety and human rights, people's well-being, and protection of the environment and ecosystems?

Further research to case studies (models and frameworks) from world class mining projects such as Australia, Canada, etc. is worthy to look at. These include real life case studies, methodological or technical advancements and sustainable development approaches, including processing and recycling/value adding, sustainable mining methods, models, and frameworks.

A final note is that mining experience from Australia is presented in this paper to show the role of mining industry as a driving force for economic development and lessons to draw and is suggestions to bridge the gap. In other words, classic contribution of Australia's mining industry to regional development via innovation, advancement, new discovery, capacity, and economy is presented to formulate, scale up/replicate, and appreciate the gap with the defies facing at Regional state level (Tigray) and Federal level (Ethiopia), and draw a lesson to other developing nations as well from one of the world's leading countries in relation to what a robust sustainable mining sector can bring to nation's economy through different themes. These themes include community, operational challenges and opportunities, environment, finance, and framework case studies aimed to explore the relationships between these themes and their potential conflicts. This is due to the different perspectives of multiple stakeholders, while retaining a fundamental view on the effective implementation of sustainability in mining and minerals industry. Big issues and ideas in geosciences to be drawn from Australian experience, which includes:

1 Smoothing the impact of boom and bust commodity cycles.

2 Energy trilemma options: security, accessibility, and sustainability.

3 Resource-driven development of regional Australia.

4 Geosciences' education and new modes of communication.

Mining operations within the regional state are expected to be an important economic catalyst for the government's export-orientated development strategy. Given the level of Ethiopia's economic development per capita resources demand is still at nascent stage. Resources demand is expected to accelerate as Ethiopia moves towards middle income bracket. Recognising the need to promote market-oriented modern mineral production, a regional government is expected to come up with a plan to bring the minerals' sector to a significant GDP's contribution, before trapped in a situation in which a desired solution is impossible to attain because of a set of inherently illogical rules or condition (i.e., Catch-22 situation).

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References

Africa Attractiveness Program 2016 [online] https://www.ey.com/za/en/issues/business-environment/ey-africa-attractiveness-program-2016-staying-the-course (accessed 30 August 2018).

Al-Weshah, R. and Yihdego, Y. (2016) 'Modelling of strategically vital fresh water aquifers, Kuwait', *Environmental Earth Sciences*, Vol. 75, p.1315, DOI: 10.1007/s12665-016-6132-1 [online] http://link.springer.com/article/10.1007/s12665-016-6132-1 (accessed 5 November 2018).

Anderson, M. (2015) 'Canadian mining company accused of exploiting Eritrea's forced labor', *The Guardian*, 20 August [online] https://www.theguardian.com/global-development/2015/aug/19/eritrea-mining-nevsun-forced-labour (accessed 24 October 2018).

AusIMM (2017) *Graduate Program Best Practice Guidelines* (*AusIMM*) [online] https://www.ausimm.com.au/content/docs/ausimm_graduate_guidelines.pdf (accessed 5 November 2018).

Ausimmbulletin (2018) *Educating the Next Generation of Geologists Educating the Next Generation of Geologists* [online] https://www.ausimmbulletin.com/feature/educating-next-generation-geologists/ (accessed 14 September 2018).

Australia's Mining Monthly (AMM) (2018) *BHP Settles in for Another 100 Years of Pilbara Iron Ore*, 9 July [online] https://www.miningmonthly.com/development/news/1342038/bhp-settles-in-for-another-100-years-of-pilbara-iron-ore (accessed 5 November 2018).

Australian Mining (2018) *CSIRO Pours Gold using Cyanide-Free Process in Australian First* [online] https://www.australianmining.com.au/news/csiro-pours-first-gold-through-cyanide-free-extraction-process/ (accessed 30 August 2018).

Bain, K. (2004) *What the Best College Teachers Do*, Harvard University Press, Cambridge, 224pp.

Boadi, S., Nsor, C.A., Antobre, O. and Acquah, E. (2016) 'An analysis of illegal mining on the offin shelterbelt forest reserve, Ghana: implications on community livelihood', *Journal of Sustainable Mining*, Vol. 15, No. 3, pp.115–119.

C2D Services Inc. (2013) *Education for Mining Development Study Background Study*, *To: Canadian International Development Agency* (CIDA) Gatineau, Quebec, Canada Mission report, 28 June 28.

Chevron Australia (2018) *Gorgon Project: An Australian Icon* [online] https://australia.chevron.com/our-businesses/gorgon-project (accessed 5 September 2018).

Cimoli, M., Dosi, G. and Stiglitz, J.E. (Eds.) (2009) *Industrial Policy and Development: The Political Economy of Capabilities Accumulation*, Oxford University Press, New York.

Cohen (2017) 'Educating the next generation of geologists educating the next generation of geologists', *10th International Mining Geology Conference in 2017*, Tasmania, Australia.

CSIRO (2018) *Cyanide-Free Gold Recovery*, *Case Study*, 28 August [online] https://www.csiro.au/en/Research/MRF/Areas/Unlocking-Australian-ores/Going-for-gold (accessed 5 September 2018).

East Africa Metals (EAM) (2018a) *Mining in Ethiopia* [online] http://www.eastafricametals.com/s/mining-in-ethiopia.asp?ReportID=649838 (accessed 2 September 2018).

East Africa Metals (EAM) (2018b) *The Mato Bula Gold Copper and Da Tambuk Gold*, Adyabo projects, Tigray, Ethiopia [online] http://www.eastafricametals.com/s/home.asp (accessed 2 September 2018).

FDI Markets and EY's Africa Attractiveness Index [online] https://www.ey.com/za/en/issues/business-environment/ey-attractiveness-program-africa-2017) (accessed 30 August 2018).

Ghorbani, Y. and Kuan, S.H. (2016) 'A review of sustainable development in the Chilean mining sector: past, present and future', *International Journal of Mining*, *Reclamation and Environment*, Vol. 31, No. 2, pp.137–165.

Govindan, K., Kannan, D. and Shankar, K.M. (2014) 'Evaluating the drivers of corporate social responsibility in the mining industry with multi-criteria approach: a multi-stakeholder perspective', *Journal of Cleaner Production*, Vol. 84, pp.214–232.

Govindan, K., Muduli, K., Devika, K. and Barve, A. (2016) 'Investigation of the influential strength of factors on adoption of green supply chain management practices: an Indian mining scenario', *Resources*, *Conservation and Recycling*, Vol. 107, pp.185–194.

GSA (2016) *The Geological Society of America Position Statement on the Importance of Teaching Earth Science* [online] https://www.geosociety.org/documents/gsa/positions/pos4_TeachingEarthScience.pdf (accessed 23 September 2018).

Gunarathne, N., Gunarathne, N., Samudrage, D., Samudrage, D., Wijesinghe, D.N., Wijesinghe, D.N., Lee, K.H. and Lee, K.H. (2016) 'Fostering social sustainability management through safety controls and accounting: a stakeholder approach in the mining sector', *Accounting Research Journal*, Vol. 29, No. 2, pp.179–197.

Hochella, M.F. (2007) 'On the cutting edge: teaching mineralogy, petrology and geochemistry', *Elements*, Vol. 3, No. 2, pp.91–126.

International Council on Mining and Metals (ICMM) (2012a) *Sustainable Development Framework*.

International Council on Mining and Metals (ICMM) (2012b) *Community Development Toolkit*.

Jembere, D. and Yihdego, Y. (2016) 'Engineering rock mass evaluation for a multi-purpose hydroelectric power plant: case of Genale Dawa (GD-3)', *Ethiopia. Journal of Geotechnical and Geological Engineering*, Vol. 34, No. 5, pp.1593–1612, DOI: 10.1007/s10706-016-0068-9 [online] http://link.springer.com/article/10.1007/s10706-016-0068-9 (accessed 5 November 2018).

JICA (2007) *Making Globalization Work for Developing Countries: Report on a Special Seminar by Prof. J. Stiglitz*, Seminar Report, JICA.

JICA (2008) *Nannankyoryoku wo Tsujita Toshi Sokushin Kankyo Seibi Purojekuto Shuryoji Hyoka Hokokusho* (*Report on the Terminal Evaluation Survey on the Triangle of Hope, Strategic Action Initiative for Economic Development*), Project Report, JICA Zambia Office, Lusaka, Zambia.

Jordan, G. (2009) 'Sustainable mineral resources management: from regional mineral resources exploration to spatial contamination risk assessment of mining', *Environmental Geology*, Vol. 58, No. 1, p.153.

Manek, N. (2018) *Rebels in Eastern Ethiopia to Seek Self-Determination Vote*, *Politics, Bloomberg*, 17 September [online] https://www.bloomberg.com/news/articles/2018-09-16/rebels-in-gas-rich-east-ethiopia-to-seek-self-determination-vote (accessed 18 September 2018).

Merwe, C. (2018) *Gold in Ethiopia*, *Spilpunt Mineral Commodities and Africa*, 13 January [online] http://spilpunt.blogspot.com/2008/01/gold-inethiopia.html?_sm_au_=iVVrWNRsH4wV7LRn (accessed 3 September 2018).

MIDROC Technology Group (MTG) (2017) *General Information* [online] http://www.midroc-ceo.com/?q=ginfo.

Mining (2012) *US$5 Billions Worth Gold Reserves Discovery in Ethiopia*, 2 January [online] http://www.mining.com/us5-billion-worth-gold-reserves-discovery-in-ethiopia/ (accessed 16 September 2018).

Mining Review Africa (MRF) (2018) *East Africa Metals Mine Permit Approved for Ethiopian Gold Projects*, 9 September [online] https://www.miningreview.com/east-africa-metals-ethiopian-gold/ (accessed 12 September 2018).

North Miner (2012) *Tigray on the Hunt for Another Bisha*, 16 January [online] http://www.northernminer.com/news/tigray-on-the-hunt-for-another-bisha/1000823414/ (accessed 2 September 2018).

Persits, F., Ahlbrandt, T., Tuttle, M., Charpentier, R., Brownfield, M. and Takahashi, K. (2002) *Map Showing Geology*, *Oil and Gas Fields and Geologic Provinces of Africa*, ver 2.0, USGS Open File report 97-470 A.

Petkova, V., Lockie, S., Rolfe, J. and Ivanova, G. (2014) 'Mining developments and social impacts on communities: Bowen Basin case studies', *Rural. Soc*., Vol. 19, No. 3, pp.211–228.

Rank, S. (2015) 'Australia mining industry: is Australia a lucky or clever country? Mineral Resources in the Republic of Serbia: A Driving Force for Economic Development', *5th International Mining Conference*, Belgrade, 19 October.

Reporter (2018) *Kenticha Tantalum Mine has been Stolen*, 12 August [online] https://www.ethiopianreporter.com/index.php/article/12484 (accessed 5 September 2018).

Ronald, E. (2017) *Reviewing Historical Trends of Geological Training in the Mining Sector*, The AusIMM Bulletin, February [online] https://www.ausimmbulletin.com/feature/reviewing-historical-trends-geological-training-mining-sector/ (accessed 7 October 2018).

Shaw, B. (2018) *Big Issues and Ideas in Geoscience*, Australian Geoscience Council Convention, Adelaide, 14–18 October.

Shimada, G. (2009) 'Industrial policy in developing countries', Presentation at the *International Workshop on Industrial Policy in Developing Countries*, German Development Institute (GDI), Bonn, 12–18 November.

Sonobe, T. et al. (2011) *Kaizen for Management Skills Improvement in Small and Medium Enterprises: An Impact Evaluation Study*, Japan PHRD Trust Fund. No. TF096317, World Bank.

Suopajärvi, L., Poelzer, G.A., Ejdemo, T., Klyuchnikova, E., Korchak, E. and Nygaard, V. (2016) 'Social sustainability in northern mining communities: a study of the European North and Northwest Russia', *Resources Policy*, Vol. 47, pp.61–68.

Theart, H., Linzer, L. and Bailey, O. (2018) *Mining Review Africa. Mineral Exploration: Why Africa?*, 1 June [online] https://www.srk.co.za/sites/default/files/File/South-Africa/pressreleases/2018/June_2018/Mining_Review_Africa_Mineral_Exploration_Why_Africa_01Jun18_p.86.pdf (accessed 3 September 2018).

Thompson, V. (2016) *Impact of the Turnbull Government's Innovation Agenda on Higher Education and Employability*, Speech to Graduate Employability and Industry Partnerships Forum by Ms. Vicky Thompson, CEO, the Group of Eight.

Thompson, R.J., Tulloch, D., Handel, D., Miedecke, J. and Tomicek, E. (2016) 'Driving haulage productivity improvements through industry-academia collaboration', in Goodz, M. (Ed.): *Proceedings Ninth AusIMM Open Pit Operators' Conference 2016*, Kalgoorlie WA, 15–16 November.

Tiainen, H. (2016) 'Contemplating governance for social sustainability in mining in Greenland', *Resources Policy*, Vol. 49, pp.282–289.

Tiainen, H., Sairinen, R. and Novikov, V. (2014) 'Mining in the Chatkal Valley in Kyrgyzstan – challenge of social sustainability', *Resources Policy*, Vol. 39, pp.80–87.

Tigrai Online (TOL) (2017) *Huge Deposit of Most Precious Gemstone Sapphire Found in Tigray State Northern Ethiopia*, 14 April 14 [online] http://www.tigraionline.com/articles/sapphire-found-in-tigrai.html (accessed 17 September 2018).

US Department of State (2016) *Ethiopia*, Bureau of Economic and Business Affairs, 2016 Investment Climate Statements, 5 July [online] www.state.gov/e/eb/rls/othr/ics/2016/af/254197.htm (accessed 23 October 2018).

Utility Magazine (2016) *Pumped hydro storage; the future for old mines?* [online] https://utilitymagazine.com.au/pumped-hydro-storage-the-future-for-old-mines/ (accessed 2 September 2018.

Wikipedia: Ethiopia [online] https://en.wikipedia.org/wiki/Ethiopia (accessed 20 August 2018).

Wikipedia: Mining in Ethiopia [online] https://en.wikipedia.org/wiki/Mining_in_Ethiopia (accessed 30 August 2018).

World Bank (2016) *Ethiopia Mining Sector Development: Policy and Legislative Options Report* (English), World Bank Group, Washington, DC, USA [online] http://documents.worldbank.org/curated/en/309111468196735603/Ethiopia-mining-sector-development-policy-and-legislative-options-report (accessed 23 October 2018).

Xiao, W., Wang, Z., Zhang, R. and Li, S. (2017) 'The 'golden ten years': underground coal mining and its impacts on land use and subsequent social problems: a case study on the Jining city region, China', *International Journal of Mining and Mineral Engineering*, Vol. 8, No. 1, DOI: 10.1504/IJMME.2017.10003214.

Yeshanew, F.G. (2017) *Crustal Evolution of the Arabian-Nubian Shield, Insights from Zircon Geochronology and Nd-Hf-O Isotope*, PhD thesis, Stockholm University, Sweden.

Yihdego, Y. (2016a) 'Hydraulic in situ testing for mining and engineering design: packer test procedure, preparation, analysis and interpretation', *Journal of Geotechnical and Geological Engineering*, Vol. 35, No. 1, pp.29–44 [online] http://link.springer.com/article/10.1007/s10706-016-0112-9 (accessed 5 November 2018).

Yihdego, Y. (2016b) 'Evaluation of flow reduction due to hydraulic barrier engineering structure: case of urban area flood, contamination and pollution risk assessment', *Journal of Geotechnical and Geological Engineering*, Vol. 34, No. 5, pp.1643–1654, DOI: 10.1007/s10706-016-0071-1 [online] http://link.springer.com/article/10.1007/s10706-016-0071-1 (accessed 5 November 2018).

Yihdego, Y. (2017) 'Engineering and enviro-management value of radius of influence estimate from mining excavation', *Journal of Applied Water Engineering and Research*, pp.1–9 [online] http://www.tandfonline.com/doi/full/10.1080/23249676.2017.1287022 (accessed 5 November 2018).

Yihdego, Y. and Al-Weshah, R. (2016) 'Engineering and environmental remediation scenarios due to leakage from the Gulf War oil spill using 3-D numerical contaminant modellings', *Journal of Applied Water Sciences*, Vol. 7, pp.3707–3718, DOI: 10.1007/s13201-016-0517-x [online] http://link.springer.com/article/10.1007/s13201-016-0517-xY (accessed 5 November 2018).

Yihdego, Y. and Drury, L. (2016) 'Mine water supply assessment and evaluation of the system response to the designed demand in a desert region, central Saudi Arabia', *Environmental Monitoring and Assessment Journal*, Vol. 188, p.619 [online] http://link.springer.com/article/10.1007%2Fs10661-016-5540-8 (accessed 5 November 2018).

Yihdego, Y. and Kwadwo, O.E. (2017) 'Investment and the third world: investors perspective', *Global Journal of Human-Social Science: E. Economics*, Vol. 17, No. 2, pp.55–60, Version 1.0, ISSN: 2249-460x & Print ISSN: 0975-587X [online] https://globaljournals.org/GJHSS_Volume17/6-Investment-and-the-Third-World.pdf (accessed 5 November 2018).

Yihdego, Y. and Nzikou, M.M. (2018) 'Application of airborne geophysics and geochemistry to characterize groundwater flow path', *Geotechnical and Geological Engineering*, Vol. 36, No. 2, pp.1175–1184 [online] https://doi.org/10.1007/s10706-017-0382-x.

Yihdego, Y. and Paffard, A. (2016) 'Predicting open mine inflow and recovery depth in the Durvuljin soum, Zavkhan Province, Mongolia', *Mine Water and the Environment Journal*, Vol. 36, No. 1, pp.114–123 [online] http://link.springer.com/article/10.1007/s10230-016-0419-z (accessed 5 November 2018).

Yihdego, Y. and Salem, H.S. (2017) 'The challenges of sustainability: perspective of ecology', *Journal of Sustainable Energy Engineering*, December, Vol. 5, No. 4, pp.341–362(22), Publisher: Scrivener Publishing, DOI: https://doi.org/10.7569/JSEE.2017.629519 (accessed 5 November 2018).

Yihdego, Y., Danis, C. and Paffard, A. (2015) '3-D numerical groundwater flow simulation for geological discontinuities in the Unkheltseg Basin, Mongolia', *Environmental Earth Sciences Journal*, Vol. 73, No. 8, pp.4119–4133, DOI: 10.1007/s12665-014-3697-4 [online] http://link.springer.com/article/10.1007/s12665-014-3697-4.

Yihdego, Y., Khalil, A. and Salem, S.H. (2017) 'Nile River's Basin dispute: perspectives of the Grand Ethiopian Renaissance Dam (GERD)', *Global Journal of Human-Social Science: B, Geography, Geo-Sciences, Environmental Science & Disaster Management*, Vol. 17, No. 2, pp.1–21 [online] https://globaljournals.org/GJHSS_Volume17/1-Nile-Rivers-Basin-Dispute.pdf (accessed 5 November 2018).

Yihdego, Y., Salem, H.S., Kafui, G.B. and Veljkovic, Z. (2018a) 'Economic geology value of oil shale deposits: Ethiopia (Tigray) and Jordan', *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, Vol. 40, Vol. 17, pp.2079–2096 [online] https://doi.org/10.1080/15567036.2018.1488015.

Yihdego, Y., Salem, H.S. and Muhammed, H.H. (2018b) 'Agricultural pest management policies during drought: case studies in Australia and the State of Palestine', *Natural Hazards Review*, Vol. 20, No. 1, pp.1–10, American Society of Civil Engineers, Reston (ASCE), Reston, VA, USA, DOI: 05018010 [online] https://doi.org/10.1061/(ASCE)NH.1527-6996.0000312.