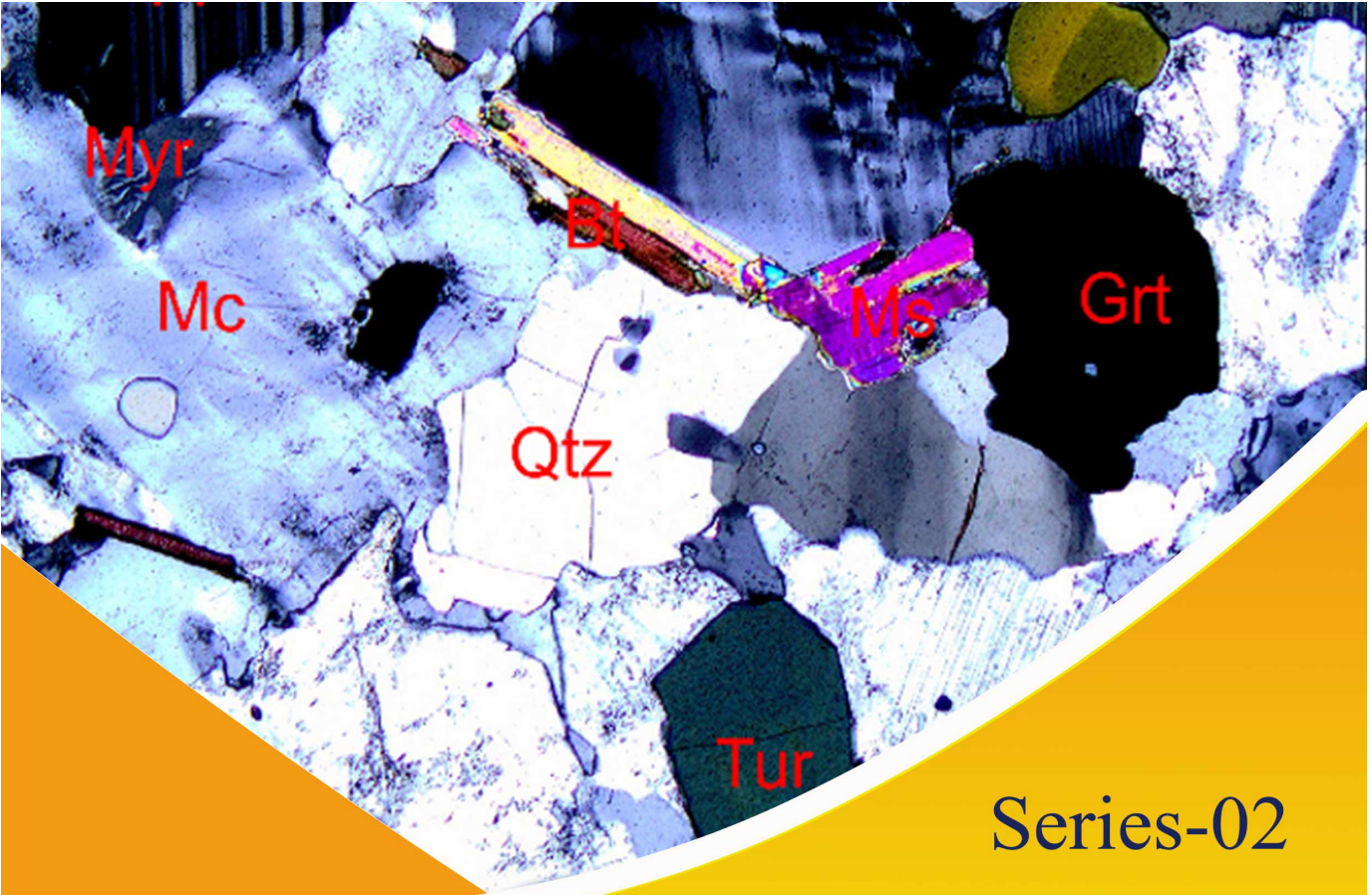

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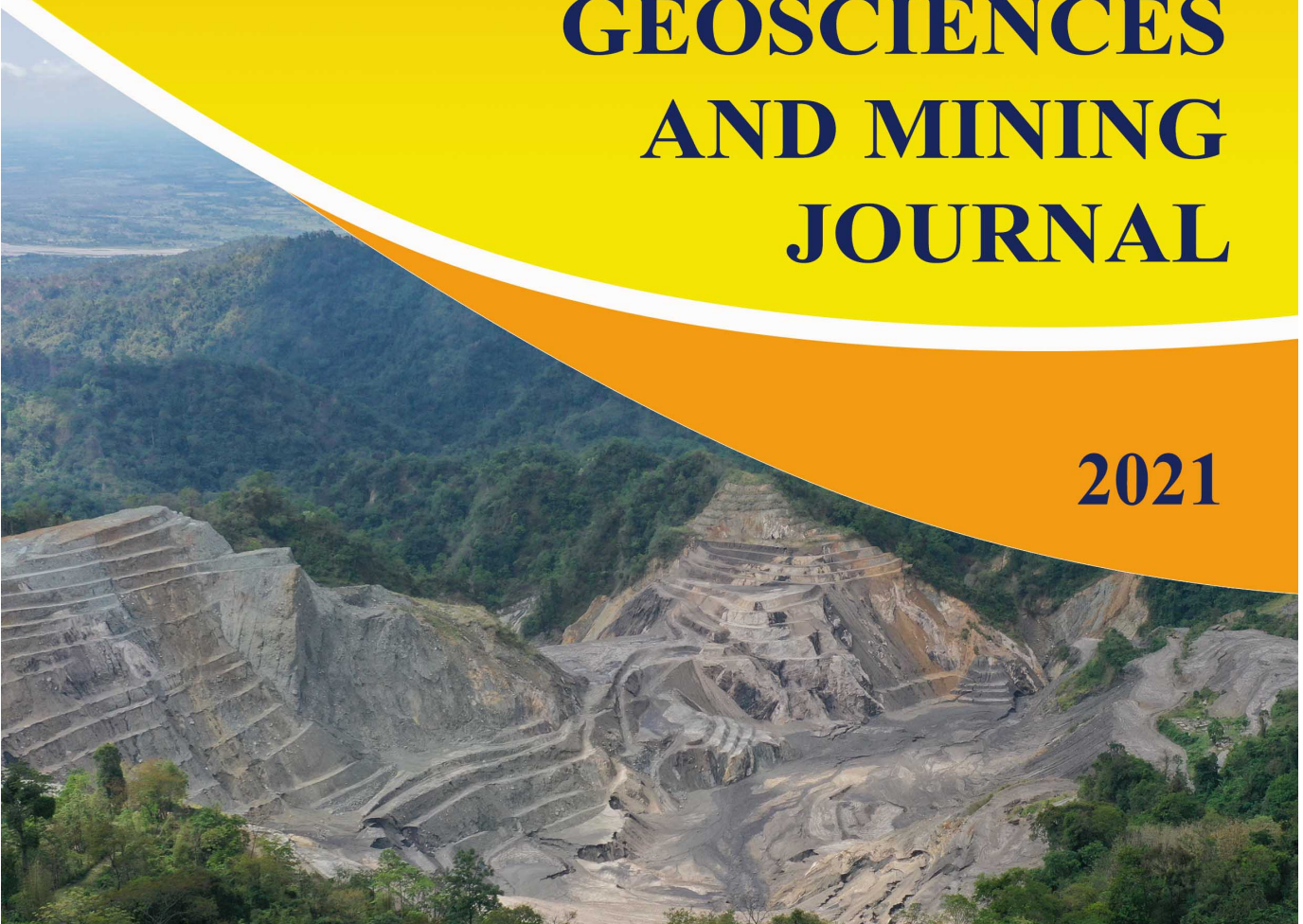
GEOSCIENCES AND MINING JOURNAL



2021

FOREWORD

It is my pleasure to bring the second edition of "Geosciences and Mining Journal of Bhutan 2021".

Currently, about 34% of the country is geologically mapped on 1:50,000 scale through field based mapping. The current knowledge-base on geology and mineral resources is a serious drawback for development of mining. In this context, the need for expediting mapping and generating comprehensive knowledge on geology and mineral resources of Bhutan using aeromagnetic survey is recommended. Further, considering Bhutan's high vulnerability to slope hazards, various techniques of landslide monitoring are presented.

In order to attract investment in the mining sector, transparent and effective licensing procedures for lease of mines and surface collection of minerals are presented together with associated regulatory reforms. An analysis of questionnaires for sustainable and responsible mining businesses indicates the adoption of innovative and greener technologies and promotion of broad-based ownership to maximize the benefits.

The importance of occupational health and safety in surface mining and its management are covered to sensitize the responsibility of the regulators, employer and employees. In addition, a mining sector at a glance is presented to disseminate mining contributions to the national economy. Finally, a policy and legislative requirement on restoration of mines are presented.

With this, I would like to express my sincere appreciation to those who have contributed in this edition and encourage others in the Department to contribute in the future series.

Mr. Choiten Wangchuk
Director General, DGM
09.06.2021

GEOSCIENCES AND MINING JOURNAL

Series-02

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AEROMAGNETIC SURVEY FOR MAPPING GEOLOGY AND MINERAL RESOURCES OF BHUTAN

Tashi Tenzin[1]

How Aeromagnetic is applied for Mapping Geology and Mineral Resources?

The crust of earth is a manifestation of 3D distribution of the rock formation. The rocks are composed of different minerals and its magnetic properties depend on the occurrence of type and concentration of iron-rich minerals (e.g. magnetite, ilmenite, hematite).

Sedimentary rocks are usually non-magnetic as compared to metamorphic and igneous rocks that have wide range of magnetic properties. Metallic ore bodies can be significantly magnetic. These variations in the magnetic properties of the rocks are induced by interaction of iron-rich minerals with Earth's magnetic field.

Remote sensing of the magnetic variations allows mapping of geological features such as distribution and patterns of rocks, structure, alteration, metamorphism and mineralization, including that of subsurface.

Scientific instruments like magnetometers can detect and measure even tiny magnetic signals. The magnetometers are mounted on aircraft or helicopter and airborne surveys or remote sensing called "Aeromagnetic Survey", usually flown along straight flight lines with fixed line spacing at a height less than 100 m above ground level, are carried out to allow fast, systematic and inexpensive geological mapping of large areas on regional (50-200 km, Figure 1) to local (5-50 km) scale. The survey gathers data on magnetic field, location and time of data recording.

The aeromagnetic survey is one of the most common geophysical methods (besides gravity survey) used for mapping geology because of its convenience to collect data as it uses passive sensors. The use of high-accuracy navigation systems such as Global Positioning System (GPS) further allows modification of flight heights of a fixed-wing aircraft surveys in a rugged topography. Although costlier, helicopters are used in mountainous regions as an alternative.

[1] Tashi Tenzin, Executive Geologist, Department of Geology and Mines, Thimphu, Bhutan.
Master of Geoscience, The University of Western Australia. Email: tashit@moea.gov.bt

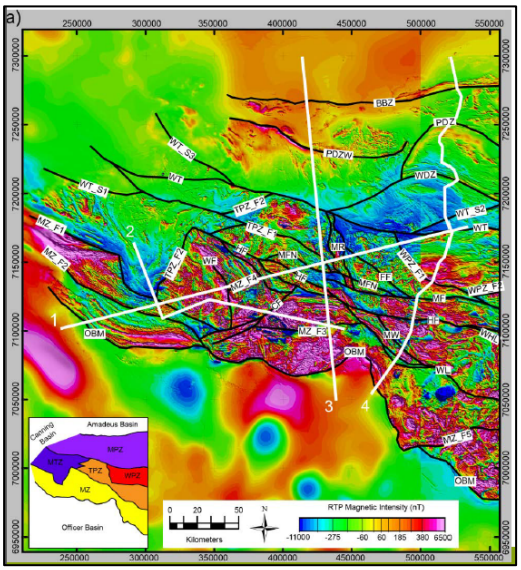

Figure 1. Reduction to Pole (RTP) Magnetic Intensity Map of Canning, Amadeus and Officer Basin, Western Australia on regional scale (50-200 km). Signals are dominated by geological features like magmatic suites, dykes, sills and faults. Source: The University of Western Australia (2015).

The aeromagnetic surveys are particularly useful in mapping of poorly exposed areas that are covered or concealed by soil, vegetation, glacier, water bodies, sand, alluvium and colluvium, as magnetic methods provide an integrated depth spectrum or anomalies of the rocks and mineral deposit sources at great depth (tens of kilometers) (cf. Pilkington, 2007).

The magnetic anomaly map is therefore a powerful tool for interpreting subsurface distribution of rocks, structures and mineralization that help better understanding of geology, structures and mineral resources of a country (Figure 2).

For example, Figure 3 shows the east-west striking dykes seen on aeromagnetic map are not shown on interpreted geological maps. This shows that the aeromagnetic surveys can allow or complement better interpretation of subsurface geology and structures.

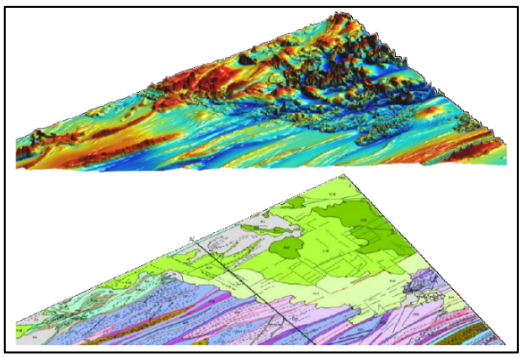

Figure 2. Example of final geological map generated from aeromagnetic data (modified from presentation of SRK Consulting, Canada).

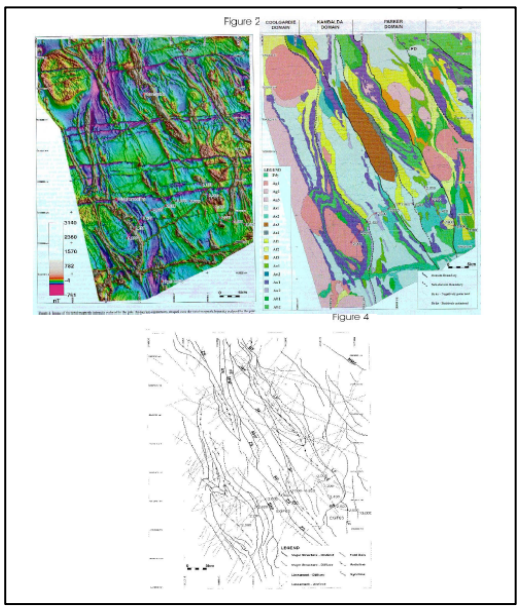

Figure 3. Comparison of aeromagnetic anomaly map of an area in Western Australia (top left) with lithological and structural interpretation maps (top right and bottom, respectively). Figure modified from Reeves (2005).

Aeromagnetic Data in other countries - Examples

Australia commenced aeromagnetic surveys since 1951. By 2007, National Airborne Geophysical Database of Geoscience Australia contained more than 1000 survey data and 27-million-line kilometers data of total magnetic intensity. Their surveys have been mostly conducted with flight line spacings of 400 m or less since 1990. The aeromagnetic data acquisition by Geoscience Australia and States at November 2012 is shown in Figure 4. Madagascar completed aeromagnetic survey on 1:100,000 and partially on 1:500,000 scale between 2002 and 2011.

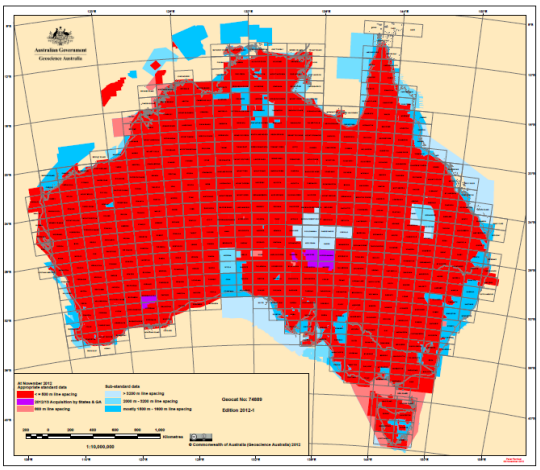

Figure 4. Aeromagnetic data acquisition by Geoscience Australia and States in Australia at November 2012. Red polygons show coverage of <=500 m flight line spacing. Source: Geoscience Australia.

Similarly, 60 percent of Mongolian territory is covered by aeromagnetic surveys on a scale of 1:200,000 by 2017. About 70 percent of India is covered by aeromagnetic surveying as of 2020 (Figure 5).

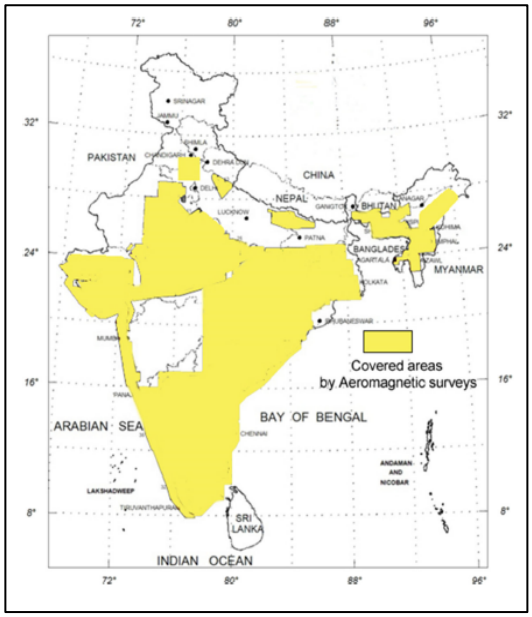

Figure 5. Aeromagnetic data coverage of India (After Patibandla & Dadhwal, 2020).

Why aeromagnetic survey is important for Bhutan?

The systematic geological mapping in Bhutan commenced as early as 1960s by Swiss geologist Augusto Gansser and geologists from Geological Survey of India (GSI). More recent works include a collaborative mapping carried out by Princeton University and Department of Geology and Mines (DGM).

The focus of their works was in generation of geological information on a country scale (1:500,000). These works led to publications of Geological Map of Bhutan by Gansser (1983), GSI (1995) and Long et al. (2011). The

geological information at this scale is however sparse and coarse, thus understanding of the geology and mineral resources of Bhutan is limited.

To improve knowledge-base on geology and mineral resources of Bhutan, GSI initiated field-based geological mapping on a regional scale (1:50,000) since 1960s. DGM continued the mapping from 9th Five Year Plan and as of 2020, about 34 percent of the country is mapped (Figure 6).

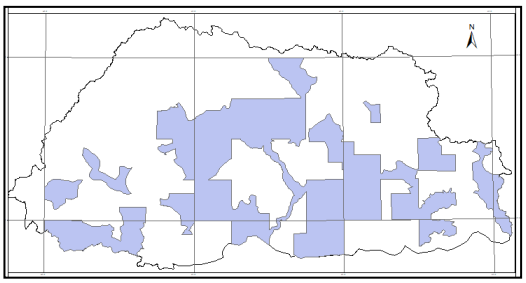

Figure 6: Geological Mapping completed on 1:50,000 scale (blue polygon). Source: DGM.

The DGM report by Girones (2019) highlights on incomplete mapping situation of Bhutan. According to the report, large surface and subsoil areas of the country is underexplored and thus true potential on metallogeny is not known. Further, the report concludes that present status of geological information is a serious drawback for the development of the mining sector.

The report highlights on the need to expedite geological mapping and recommends that the field-based mapping should be complemented by modern mapping techniques like airborne geophysical survey data (*aeromagnetic or gamma ray spectrometer surveys*) and stream sediments geochemical survey data in order to build comprehensive geological and mineral resources knowledgebase of Bhutan.

Given rugged terrain topography of Bhutan with vast vegetation and soil cover, the aeromagnetic surveys can overcome challenges of mapping difficult, inaccessible and poorly exposed surface areas.

How aeromagnetic data can be used for other geoscience purposes?

Active tectonics, fragile geological environment, steep topography and climate change make Bhutan Himalaya highly vulnerable to geological hazards like landslides and earthquakes. The recent probabilistic seismic hazard and risk analyses for Bhutan by Stevens et al. (2020) show Bhutan has a significant level of risk associated with seismic hazard.

Faults (a source of earthquakes) and geological structures or lineaments (causative factor of slope instability) detected by aeromagnetic will form useful for better understanding of seismic and slope hazards. The aeromagnetic data on lineaments like faults, fractures, dykes in sedimentary

rocks can also provide valuable information on groundwater aquifer and petroleum systems among others.

How much would aeromagnetic survey cost for Bhutan?

According to DGM report by Girones (2019), the airborne aeromagnetic and gamma-ray spectrometric surveys with flight line spacing of 500 m will cost about US $13 million, equivalent to Nu. 962 million. The airborne surveys be supported by field geological mapping, geochemistry, geochronology, remote sensing, panning and metallogenic surveys.

The integrated mapping program to produce geological and metallogenic map of Bhutan on 1:50,000 regional scale along with establishment of computerized geodata management and mineral rights cadastre systems and formulation of geological survey strategic plan is expected to take 4 years and cost about US $21 million, equivalent to Nu. 1.554 billion.

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LANDSLIDE MONITORING

Tashi Tenzin[1]

What is Landslide Monitoring and Why is it important?

A landslide is the movement of a mass of rock, earth or debris down a slope (Cruden, 1991). The velocity of movement of landslides can vary depending on geological, topographical, hydrogeological, rainfall and other factors. Cruden & Varnes (1996) classified landslides based on the movement velocities (Figure 1).

Since landslide pose great threats to lives and properties, it is important to recognize the hazards and deal with proper solutions. Landslide monitoring is one of the solutions to reduce risks associated with landslide hazards.

In landslide monitoring, data acquisition using scientific techniques on physical parameters such as displacement, loadings, inclination, cracks, vibrations, etc. related to movement of landslide are carried out. The data are analyzed to disseminate information for decision making to mitigate or reduce risks.

Types of Landslide Monitoring

Monitoring can be classified into three types: (1) knowledge monitoring, (2) control monitoring and (3) emergency monitoring.

Knowledge monitoring is quantitative assessment or testing of behavior of usually a wide spread slopes over time to identify areas affected by potential failures in order to enable prioritization of interventions. In control monitoring, quantitative monitoring (usually periodic) on evolution of the well-known

Velocity class	Description	Velocity (mm/s)	Typical velocity	Response[a]
7	Extremely rapid	5×10^{3}	5 m/s	Nil
6	Very rapid	5×10^{1}	3 m/min	Nil
5	Rapid	5×10^{-1}	1.8 m/h	Evacuation
4	Moderate	5×10^{-3}	13 m/month	Evacuation
3	Slow	5×10^{-5}	1.6 m/year	Maintenance
2	Very slow	5×10^{-7}	16 mm/year	Maintenance
1	Extremely Slow			Nil

Figure 1: Classification of landslides based on movement velocity (Cruden & Varnes, 1996). Source: Natural Hazards Control and Assessment (NHAZCA Srl) (2017).

[1] Tashi Tenzin, Executive Geologist, Department of Geology and Mines, Thimphu, Bhutan. Master of Geoscience, The University of Western Australia. Email: tashit@moea.gov.bt

slope failures is conducted to support management of the risks associated to failures. Emergency monitoring, also known as early warning systems, is monitoring of hazardous slopes with continuous data acquisition with high temporal rate to provide alert or early warning (often automatic or real time basis) when risks become inacceptable.

The types of monitoring during landslide evolution with respect to displacement and time is shown in Figure 2. The knowledge monitoring is related to long term processes of slope failures during initial stage with low and gradual displacement rate of movement. The control monitoring is related to long term processes during intermediate stage with erratic and moderate displacement. Emergency monitoring is related to short term processes during final stage with quick displacement resulting catastrophic event.

Similarly, the relevance of space (scale) and time for monitoring types is shown in Figure 3. For example, the knowledge monitoring as compared to control monitoring and emergency are related to monitoring of slope failures in large area over long period of time.

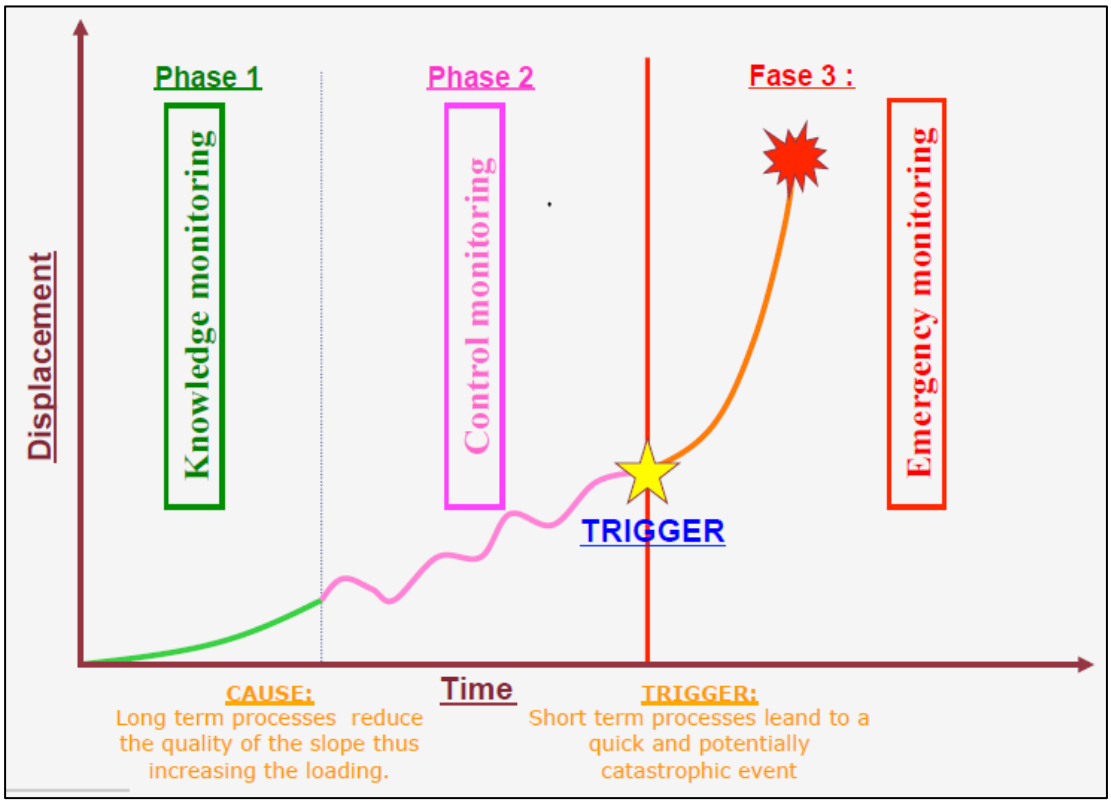

Figure 2. Types of monitoring during landslide evolution based on Displacement and Time. Source: NHAZCA Srl (2017).

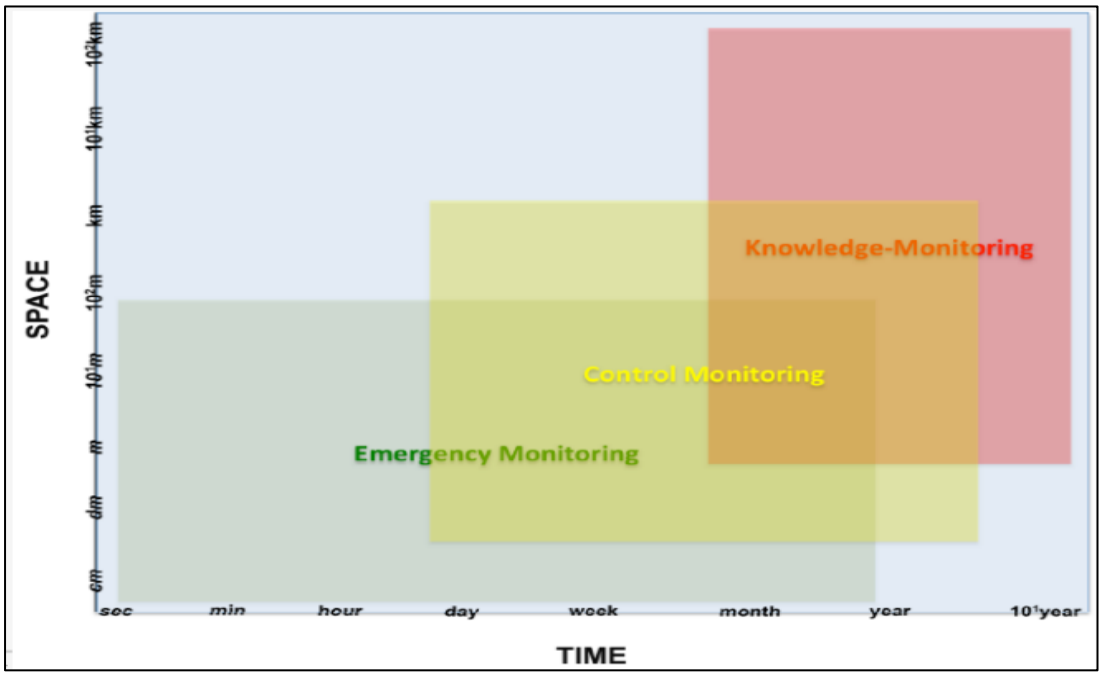

Figure 3. Types of monitoring based on Space (Scale) and Time. Source: NHAZCA Srl (2017).

Time Factor in Monitoring

Time factor is used for classification of landslide monitoring into short term and long term. Short term monitoring refers to monitoring of landslide in minutes, hours, days and months term. Long term monitoring refers to monitoring of landslide in years and decades term.

The classification based on time factor defines the selection of equipment and specifications such as durability and type of equipment, data acquisition mode, precision and accuracy, temporal frequency on data collection, etc.

Scale Factor in Monitoring

The scale factor that is dependent of space (small and large) defines the spatial information density of monitoring systems (Figure 4). It involves four systems a) Point based, b)

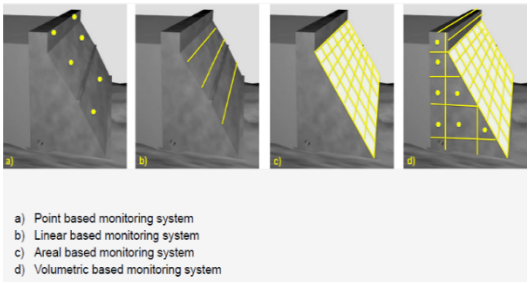

Figure 4. Spatial information density of monitoring systems based on Space (Scale) factor. Source: NHAZCA Srl (2017).

Linear based, c) Areal based, and (d) volumetric based monitoring system.

Monitoring Systems - Instruments

Geotechnical instruments for landslide monitoring are of two main types: (1) Contact and (2) Remote monitoring systems. Contact systems involve contact between instrument and ground. Remote systems use sensors based on electromagnetic waves.

While contact systems are most common method used because of its capability to measures all the key geotechnical parameters with wide range of depth, popularity of remote systems is also growing in recent years as it has capability and convenience to monitor large areas with higher spatial information density. The evolution or history of contact and remote monitoring instruments and their use in monitoring of different parameters of landslide deformation are shown in Figure 5 and 6, respectively.

Monitoring Network

Landslide monitoring is applied in three ways:

(1) Single instrument;
(2) Network of same instruments;
(3) Integrated network of different instruments;

Integrated network is preferred because of its capability to support comprehensive understanding of the landslide behaviors. It enables better decision making particularly important in Emergency Monitoring (i.e., Early Warning Systems).

1950s	1960s	1970s	1980s	1990s	2000s	2010s
Stressmeter			Continuous Monitoring			
Levelling			US standards	Early Warning Monitoring	European Standards	Digital Image Correlation
Theodolite			Total Station	GSM data transmission	Laser Scanner	Drones
Extensometer	Vibration Monitoring		Time Domain Reflectometry	Fibre Optics technology	Multi-parametric borehole systems	Web based data management
Piezometer	Submarine Monitoring	Datalogger	In place inclinometers	GNSS Technology	Interferometric Radar technology	Wireless monitoring
Load cell	Inclinometer	Laser distance-meter				

Figure 5. History of monitoring systems invention. Source: NHAZCA Srl (2017).

Parameters	Contact instruments	Remote instruments
Deformation Displacement	Surface and probe Tiltmeter, Inclinometer, Extensometer, Liquid Level Gauge, Crack Gauge, TDR, Fibre Optic, Pendulum, Deflectometer, Convergence Gauge,	GNSS, Total Station, Optical Levelling, Lidar, Satellite and Terrestrial Interferometric Radar, Digital Image Correlation and Photogrammetry
Vibration Acoustic emission	Accelerometer, Velocimeter, Seismometer, Geophone	Terrestrial Interferometric Radar, Digital Image Correlation
Groundwater pressure	Piezometer, Observation Well	n.a.
Stress	Earth Pressure Cell, Stress-meter	n.a.
Load & Strain	Load Cell, Strain Gauge	n.a.
Temperature	Thermometer, Thermocouple	InfraRed Camera

Figure 6. Use of monitoring systems for monitoring of different parameters in landslide deformation. Source: NHAZCA Srl (2017).

Performance Features of Monitoring Systems – for selection and designing of monitoring plan

The key performance features of contact, terrestrial remote, and remote monitoring systems are provided in Figure 7, 8, and 9, respectively. The features are key in selection and designing of monitoring plan based on its capability, limitations, affordability or cost.

For instance, while spatial coverage and data collection density of remote contact systems like Satellite InSAR and Aerial LiDAR are excellent, however, its temporal resolution and underground effectiveness are nil when compared to Inclinometer and TDR-Optical Fibre.

Further, it is important to consider the applicability of monitoring systems for different types of landslide failures as shown in Figure 10. For example, Extensometer, Seismic-Acoustic and Terrestrial LiDAR are highly effective or applicable for monitoring of rock fall or topple, whereas Inclinometer, Piezometer, Satellite InSAR are not applicable or effective in such monitoring requirement.

	Accuracy	Interaction with the slope	Spatial coverage	Temporal resolution	Underground effectiveness	Affordability	Cost
Crackmeter	Excellent	Small	Point	Excellent	no	Excellent	Low
Extensometer	Very Good	Small / Medium	Point	Excellent	yes	Excellent	Medium/Low
Inclinometer	Good	High	Point	Excellent	yes	Good	High/Medium
Distancemeter	Excellent	Small	Point	n.d.	no	Excellent	Medium/Low
TDR – Optical Fiber	Good	Medium	Linear	Excellent	yes	Medium/ Low	Medium
Presure cells	Good	Medium	Point	Good	no	Medium	Medium

Figure 7. Key performance features of Contact Monitoring Systems. Source: NHAZCA Srl (2017).

	Accuracy	Interaction with the slope	Spatial coverage	Temporal resolution	Underground effectiveness	Affordability	Cost
Terrestrial RADAR	Excellent	Very Low	Good/Very good	Very good	no	High	High
Robotic Total Station	Very good	Low	Good	Good	no	High	Medium
Optical Levelling	Good	Medium	Medium	n.d.	no	High	Medium/ Low
Terrestrial LiDAR	Good/Low	Very Low	Good/Very good	good	no	High	High
Terrestrial Photogrammetry	Low	Very Low	Good/Very good	Very good	no	High	Medium/ Low
GNSS	Good	Medium/ High	Low	Very good	no	High	High/ Medium

Figure 8. Key Performance Features of Terrestrial Remote Monitoring Systems. Source: NHAZCA Srl (2017).

	Accuracy	Interaction with the slope	Spatial coverage	Temporal resolution	Underground effectiveness	Affordability
Satellite InSAR	Very good	Very low	Excellent	Low	No	Good
Digitital Image Correlation	Medium	Very low	Very good	Low	no	Good
Aerial Lidar	Medium	Very low	Very good	n.d.	no	Good

Figure 9. Key Performance Features of Remote Monitoring Systems. Source: NHAZCA Srl (2017).

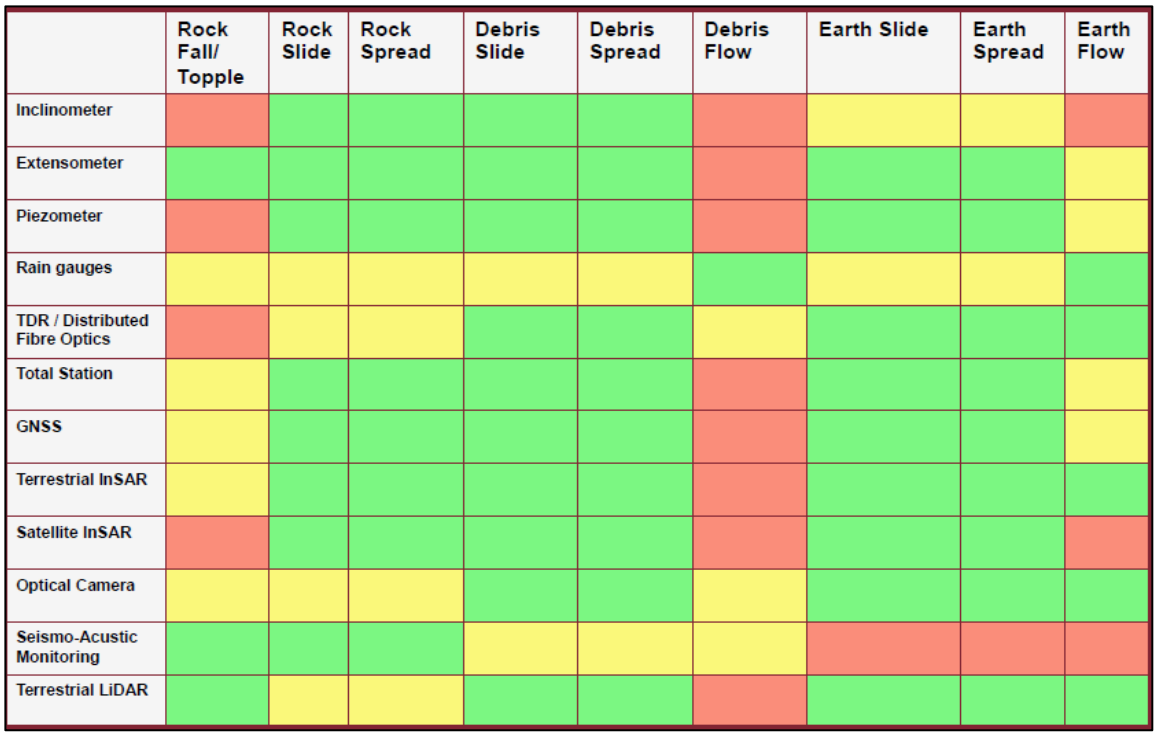

Figure 10. Applicability of monitoring systems for different types of landslides. Red colour indicating not applicable, yellow – moderately applicable and green indicating highly applicable. Source: NHAZCA Srl (2017).

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Courtesy

This article is written using "Course Materials of Training of Trainers (ToT) on Landslide Monitoring and Design of Monitoring Programs for Landslides in Bhutan" conducted in Rome, Italy in 2017 by Natural Hazards Control and Assessment (NHAZCA), Spin-off Company of "Sapienza" University of Rome.

MANAGEMENT OF MINERAL RIGHTS

Karma Chophel[1]

Introduction

Every aspect of our lives relies on minerals or mineral products, such as metals, coal, industrial minerals and constructions aggregates and stones. Recycling of metals and minerals does not meet the requirement of the society and substitutes to natural mineral produce is limited.

In addition, mining also plays an important role in addressing climate change through supply of critical minerals (e.g. lithium, graphite, REE) for production of green technologies such as electric car batteries, solar panels and wind turbines. Thus, mining will remain critical part of our lives for unforeseeable years (International Council for Metal and Mining, 2021).

In this context, mining sector is recognized as one of the five jewels of the economy in Bhutan. The sector is expected to play significant role in revival of country's economy at times of COVID-19 pandemic.

It is imperative that the government ensure sustainable management of minerals with transparent and efficient licensing procedures. The mining cadastre is crucial for an effective management of the minerals rights and attracting investment by ensuring security of tenure and promoting transparency. While rest of the other developed countries are embracing the impact of the fourth industrial revolution, sometimes referred to as Industry 4.0 which is characterized by technologies which integrate the physical, digital and biological spheres, it is never late for Bhutan to undertake necessary reforms in minerals rights management. The timing cannot be better than this when the mining legislation amendment is being undertaken.

Some of the best practices being adopted around the world and issues in practices being implemented in Bhutan are described in the following sections.

Principles for Effective Mineral Rights Management

The primary focus of the Mineral Rights Cadastre (MRC) is to protect and guarantee the rights of both the State and the lessee. To achieve this balance, it is

[1] Karma Chophel, Executive Engineer, Department of Geology and Mines, MoEA, Thimphu, Bhutan. Master of Professional Engineering, The University of Western Australia. Email: kchophel@moea.gov.bt

essential for the mining cadastre to make (1) transparent, (2) objective and (3) non-discretionary decisions.

1. Transparency

The poor record of governance in many resource-rich States and its damaging effects on their development have encouraged a consensus around transparency as a policy response. The guiding idea behind the new norms, standards, and legal rules is that if more information is available to the public, governments and extractive industries will become more accountable and resource revenues will be better spent, to the advantage of the countries concerned (Cameron & Stanley, 2017).

Transparency of cadastral procedures can be ensured only with legal and regulatory framework. The legal framework should include:

- Simplified and detailed requirements for obtaining, maintaining and terminating mineral rights. Any lessee, permit holder, applicant, or interested individuals or companies must be able to access detailed information about the requirements and conditions of applying for mineral rights;
- Maintaining a specific book of register or database, with the exact date, hour, and minute of application for all mineral rights;
- Deadlines for specific timeframes within which applicants, lessees, permit holders and cadastre officials are required to take certain actions or make certain decisions;
- Requirements for written notification of any decision affecting applications or existing grants of mineral rights. For instance, if the application for a new license has a mistake, the applicant must have the right to correct the error (within the predetermined deadline) before the application can be rejected. Related to this, it is very important that the legal framework and cadastral procedures determine the minimum required conditions for an application to be accepted by the MRC (Girones, Pugachevsky, & Walser, 2009).

At a minimum, the following types of information should be made available to the public:

- The cartographic position of granted mineral rights as well as any pending applications**;**
- The cartographic position of areas where mining activity is restricted or prohibited**;**
- The registry book for verification of license application, sequence, and chronology**;**
- Relevant cadastral information about any granted or applied mineral right, including, at

minimum, the application date, name of the applicant, applied-for or granted mineral substances, and expiration date (in the case of licenses already granted (Girones, 2019).

2. Objective evaluation criteria

The main principle is removal or minimization of subjective evaluation criteria as preconditions for granting mineral rights. It means that all the criteria and parameters to be considered and evaluated for granting a license must be objective and not subject to interpretation. This avoids the risk of discretion that would arise every time a rule or procedure needs interpretation and prevents the application of different interpretations to different applicants or holders. Some of the criteria can be objectively evaluated while others like financial and technical capacity are very difficult to evaluate objectively(Krakoff, 2009).

The system should guarantee equal conditions for all applicants without discrimination. Some of the measures adopted by countries to eliminate discretion in the implementation of their mining laws are:

- Removing any requirement by the applicant to demonstrate either the existence of a commercially viable deposit, or the applicant's financial and technical ability to carry out a activity;
- Eliminating or standardizing the work, investment and or production requirements, and the means of satisfying them;
- Limiting the grounds and procedures for the cancellation of mineral rights(Girones et al., 2009).

Although these conditions work well in countries where they have been adopted, they cannot necessarily be directly exported to other geopolitical contexts where traditions, the structure of mining sector, and the general legal framework are different.

3. Nondiscretionary decisions

In some countries, the conditions for granting mineral rights are variable and negotiable. Essential parameters such as the duration of validity or lease rent differ from one lease to another. Such contractual regime is best to avoid since it involves case-by-case negotiations that are discretional, lack transparency, and are potential source of corruption.

Avoiding discretionary decision making can be achieved by predetermining the legal and regulatory framework and the standardized conditions for the granting of mineral licenses (duration, size, geometry, fees, conditions for renewal, and so on). Based on these legal provisions, the MRC should ensure that standard principles are applied to any type of applicant and permit holder.

Diagnosing the case in the country

As per Girones (2019), the cadastral procedures of Bhutan are complex, fragmented and includes unnecessary steps. Following are some of the issues observed with reference to the principles of the effective mineral rights management:

Access to the cadastral information

The cadastral data and maps are not available in the public domain. Such situation is expected to affect the transparency in the licensing procedures.

No dedicated unit for the cadastre

Lack of updated cadastral maps and registries indicate the absence of a unit solely responsible in the management of the licensing activities.

Turnaround time (TAT)

TAT for each process need to be well defined and strictly followed. Current system lacks accountability and service delivery has been impacted without fixed deadlines. It results in indefinite pending of applications, which potentially can discourage investments in the sector.

For instance, National Land Commission (NLC) and National Environment Commission (NEC) has huge role in the processing of mining lease for issuance of sectoral clearances. In absence of strict implementation of TAT, timely issuance of license by MoEA is impacted. The deadline should also apply to the applicants for submission of required documents. It is therefore, necessary to prescribe and implement TAT strictly by all the stakeholders.

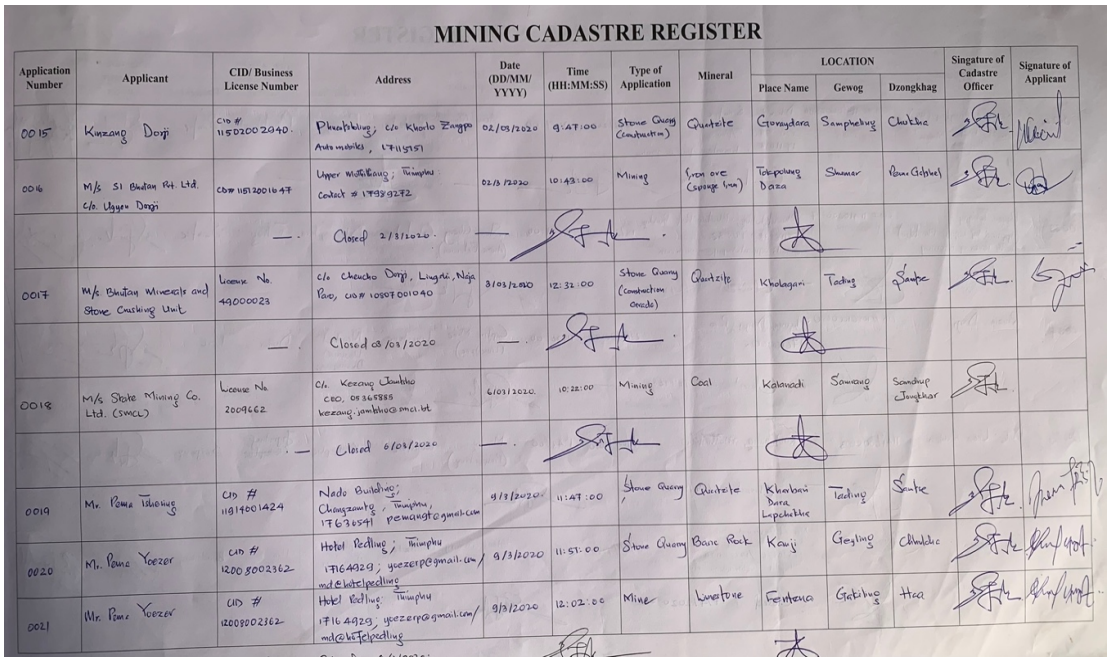
Registration Methodology

The earlier practice of registering all mineral rights application in a general register log book along with other incoming letters does not meet the requirement of best practices. As this practice had no provision for information such as hour and minutes or signature of applicant, it has become challenge in ensuring the transparency on first-come, first-served principle.

Based on this observation, dedicated mining cadastre register has been introduced since 2020 with mandatory fields such as sequential number, applicate date, hour and minute, applicant's name, type of applied license, location details, applicant signature countersigned by the official receiving the application. Figure 1 shows the new mining register being implemented.

The Geometry of Minerals Rights

Beside effective management principle, mining cadastre need to be equipped with technical capacity and infrastructures. One of the key mandates of the MRC is to fix and delimitate the polygon and topology of mineral rights.



MINING CADASTRE REGISTER

Application Number	Applicant	CID/ Business License Number	Address	Date (DD/MM/YYYY)	Time (HH:MM:SS)	Type of Application	Mineral	LOCATION			Singature of Cadastre Officer	Signature of Applicant
								Place Name	Gewog	Dzongkhag		
0015	Kinzang Dorji	CID # 11502002940	Phuentsholing, c/o Khorlo Zangpo Auto mobiles, 17115151	02/03/2020	9:47:00	Stone Quarry (Construction)	Quartzite	Gomaydara	Samphelling	Chukha		
0016	M/s SI Bhutan Pvt. Ltd. c/o Ugyen Dorji	CDN# 11512001647	Upper Motithang, Thimphu Contact # 17989272	02/3/2020	10:43:00	Mining	Iron ore (Sponge Iron)	Tshepsheng Daza	Shumar	Pema Gatshel		
		—	Closed 2/3/2020	—								
0017	M/s Bhutan Minerals and Stone Crushing Unit	License No. 49000023	c/o Chencho Dorji, Lingkhi, Naja Pao, CDN# 10507001040	3/03/2020	12:32:00	Stone Quarry (Construction aggregate)	Quartzite	Kholagari	Tading	Samtse		
		—	Closed on 03/03/2020	—								
0018	M/s State Mining Co. Ltd. (SMCL)	License No 2009662	C/o. Keezang Chembho CEO, 03 365885 keezang.jambbho@smci.bt	6/03/2020	10:22:00	Mining	Coal	Kalamati	Samtse	Samtse Jungkhar		
		—	Closed 6/03/2020	—								
0019	Mr. Pema Tshering	CID # 11814001424	Nado Bunthing; Chhuzomtse, Thimphu, 17630541 pemangt@gmail.com	9/3/2020	11:47:00	Stone Quarry	Quartzite	Khambani Dara Lapchutse	Tading	Samtse		
0020	Mr. Pema Yoezer	CID # 12008002362	Hotel Pedling; Thimphu 17164929; yoezerp@gmail.com/ md@hotelpedling	9/3/2020	11:51:00	Stone Quarry	Bare Rock	Kanji	Gesling	Chhukha		
0021	Mr. Pema Yoezer	CID # 12008002362	Hotel Pedling; Thimphu 17164929; yoezerp@gmail.com/ md@hotelpedling	9/3/2020	12:02:00	Mine	Limestone	Fenthenca	Gatshog	Haa		

Figure 1. Mining cadastre register under implementation.

The aim is to avoid physical boundary pillars.

Topographic map covering the whole country and developed geodetic network is very essential for accurate positioning of mineral rights. Use of technology such as satellite images, the GPS and GIS tools can help avoid mistake of positioning and issue of overlap of leased area.

The following subsection presents the good practices and solutions that have been adopted to address the challenges of positioning mineral rights.

The Cadastral Unit (CU) concept

A CU is a quadrangular polygon with constant dimensions that is referred to and has a fixed position within a system of coordinates (Girones et al., 2009).

Before the CU concept was developed, there were no restrictions on the shape, geometry, and position of mineral rights, leading to a number of problems, including frequent overlaps between adjacent leases and the presence of areas that were geometrically blocked for applications.

The evolution of a modern CU began with restrictions on the geometry and positioning of mineral rights. These restrictions required the borders of the surface areas of mineral rights to be polygonal, regular, and parallel to the coordinate system used in national maps (Figure 2).

Later, it evolved into a criteria where there is requirement of minimum dimension in a polygon. The minimum size of a single mineral rights area would equal the dimensions of the CU; for example, if a CU were 500 m x 500 m, then that would be the minimum area

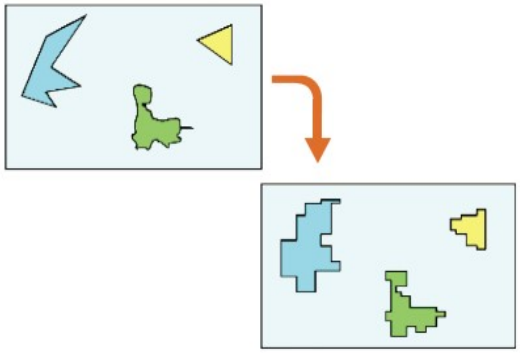


Figure 2. Evolution from "noncellular" polygons to the geometry controlled by polygons made up of individual cadastral units(Girones, 2018)

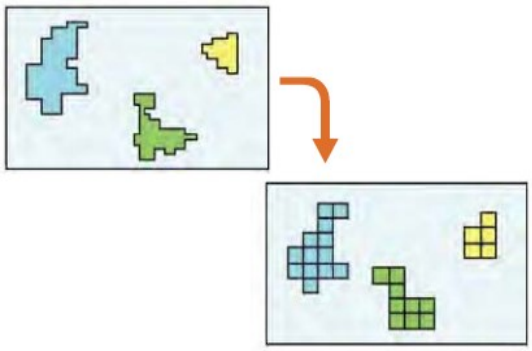


Figure 3. "prefixed cellular" polygons controlled by a predefined and standard grid (Girones, 2018).

allowed. Any mineral leases should always be made up of a certain number of CU (Figure 3).

Further, the polygons corresponding to minerals rights must be located within a predefined and standard grid and cannot be placed randomly (Figure 4).

There is no type of CU that has standard dimensions with universal application. The selection of the characteristics of the CU for each country should be made according to the characteristics and infrastructure of that country.

The parameters to be considered in choosing a CU include:

- *Type of grid*. The use of existing coordinates on already available maps should always be preferred over a mining-specific grid;
- *CU size*. Key to the successful implementation of a cadastral grid is the selection of a suitable grid size. The selection of the dimensions of the CU will depend on the scales and accuracy of available maps and the geodetic framework of each country, as well as on the characteristics of the mining activities in each country and the geometry of any preexisting mining rights. The block size ideally needs to accommodate all types of rights, ranging from very small artisanal mining rights to very large prospecting rights. (Spatial Dimenstion South Africa Pty Ltd, 2017).
- *Coordinates delimitating the CU*. The selection of coordinates will depend on which systems have been used in the available national maps of each country.

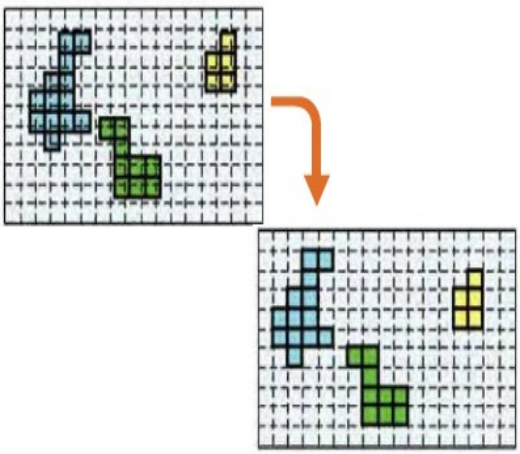


Figure 4. "prefixed cellular" polygons controlled by a predefined and standard grid (Girones, 2018)

In addition to the criteria discussed above, another factor to be considered before the selection of the CU size is the complexity of the transitional period for the CU implementation.

The use of the CU system also implies additional restrictions as follows:

- any polygon included in the application for a license should be composed of an exact number of CUs;
- CU is indivisible and fractionating is not allowed;
- all of the applied units should be contiguous at least by one side;
- two or more isolated polygons or polygons in contact by only one vertex cannot be included together in a single mineral right;
- polygons containing empty spaces inside cannot be accepted.

An exception to this rule may be cases where the CU overlaps a national border or the boundaries of protected areas or other restricted areas. Table 1 present the dimensions of CU being adopted by different countries.

Table 1. Characteristics of CU Systems adopted around the world (Girones, 2018).

Country	Scale	Coordinate	CU Dimension (m)
Algeria	1:50,000	UTM	100x100
Bolivia	1;50,000	UTM	500x500
DRC	1:200,000	Geographic	927x927
Madagascar	1:100,000	Local UTM	625x625
Mauritania	1:200,000	UTM	1,000x1,000
Mongolia	1:50,000	Gauss-Krugger	500x500
Mozambique	1:50,000	Geographic	463x463
Nigeria	1:100,000	Geographic	463x456
Peru	1:50,000	UTM	1,000x1,000

The use of GPS Technology

GPS is a tool which helps to determine the position of CUs and mineral rights in the field whether for applicants, lessees, permitholder, or the cadastre administration. The effective use of GPS technology requires that GPS-measured coordinates be correctly plotted over a suitable map. Thus, the applicability of GPS technology in the positioning of the mining leases depends on three basic factors:

- Maps with suitable scale and accuracy;
- Geodetic network with suitable accuracy and density;
- Transformation parameters that allow the transfer of coordinates and projection system of the GPS to the coordinates of the maps.

The existing system and infrastructure

Bhutan has topographic map of the entire country at 1:50,000 scale. All cartographic and geodetic information is maintained by the National Land Commission (NLC).

In 2004, the NLC (then Survey of Bhutan) transformed and migrated this cartography towards a new system based on the WGS ellipsoid referred to the DRUKRef 03 with TM projection. This transformation was based on a recalculation of the primary geodetic network with high accuracy GPS measurements.

It is very important to mention that the DRUKRef 03 system could be considered as practically equivalent to the WGS-84 and consequently, the field

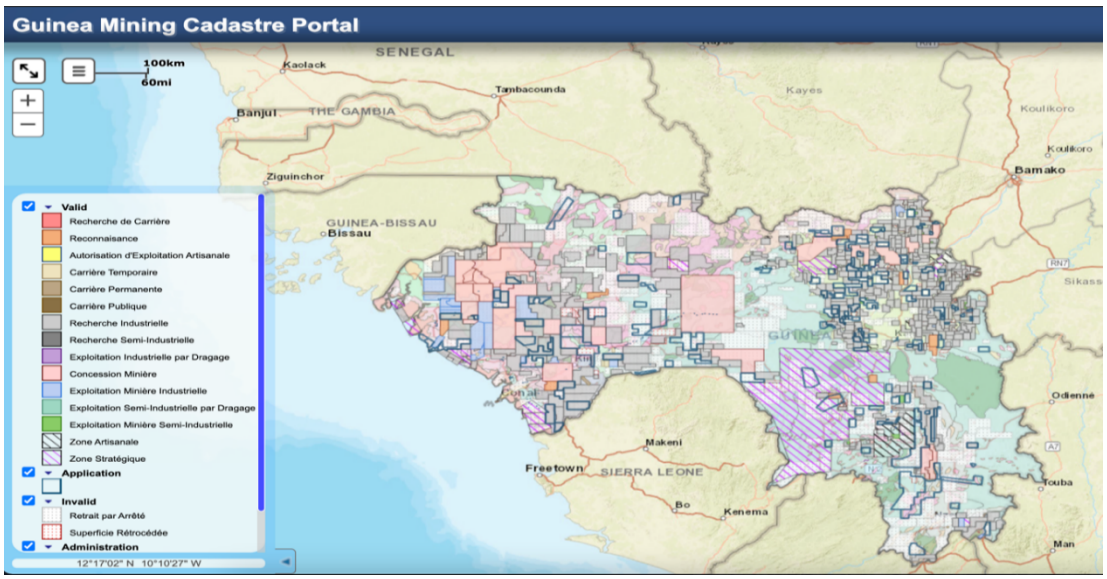


Figure 5. depicts the typical mining cadastral map developed using the cadastral unit size of 100 mx100

measurements realized with GPS can be accurately plotted on the maps without any additional transformation.

More recently, these maps have been digitized and vectorized, existing a complete cover for all the country in digital format. In addition, the southern parts of the country are also available at 1:25.000 scale.

The current practice does not have any restriction on the shape and geometry of the leased area of a mine. Blocking of areas which are not useful for new application and potential overlapping are some of the issues observed.

As per the Girones (2019), Bhutan has complete coverage of maps at a suitable scale for most of the country. The available maps allow the plotting of the GPS coordinates without any transformation. Consequently, it can be concluded that the present available infrastructure in Bhutan is ideal for the implementation of a computerized cadastre based on a geo-referred GIS, without requirements of additional geodetic or cartographic works. However, rugged topography may pose challenge in systemic application of CU.

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REGULATORY REFORMS IN MINING SECTOR OF BHUTAN - A SYNOPSIS

Chabilal Dhital [1]

Introduction

The mining sector needs to evolve and move forward progressively in line with the periodic updating of mining regulations and standards to reflect changing knowledge and best practices. To manage mining and the geo-scientific activities in the country, the first mining law, Mines and Minerals Management Act (MMMA) was enacted in 1995. Subsequently, the Act was supplemented by Mines and Minerals Management Regulations 2002 (MMMR).

Over the years, there were many reforms being undertaken to attract the investment in the mining sector through policy interventions though adoption of Economic Development Policy (EDP) 2016 and Mineral Development Policy (MDP) 2017, which gave the major impetus for reforms to accrue the benefit of the mining sector. Further, there was political will of the subsequent government to put mining at the forefront leading to identification of the mining sector as one of the five jewels of economy. In keeping with the demand for minerals and stones from domestic

and neighboring countries, the DGM has lease number of mines. The Figure 1 shows the trend and total number of mines leased over last 17 years (2004 to June 2021). Further 75 sites for mineral collections including two sites for artisanal mining.

In addition, as a commitment to adoption of sustainable development in mining, Bhutan joined Inter-governmental Forum for Mining and Metals (IGF) as a 70th member country in 2019 to get the benefit of best international practices on mining and environment.

The Ministry of Economic Affairs (MoEA) has under taken several reforms in the management and regulation of mining sector starting from revision of legal frameworks to administration.

Some of the important reforms are described under following section:

[1] Chabilal Dhital, Executive Engineer, Department of Geology and Mines, Thimphu, Bhutan. Master of Geotechnical Engineering and Engineering Geology; University of New South Wales, Sydney, Australia. Email: cdhital@moea.gov.bt

i. Introduction of Mines Monitoring Tool kits;
ii. Performance Evaluation of Mines & Quarries;
iii. Mine Restoration Guidelines (MRG), 2021;
iv. Guidelines for Surface Collection of Minerals 2020;
v. Revised Taxes and Levies Act 2016; and
vi. Mines and Minerals Bill 2020.

Currently, there are 81 active mines and quarries spread across 15 Dzongkhags. These mining activities are predominantly present in the central, southern, eastern and western regions of the country with no leased mines in the northern part of the country.

Figure 1. Total number of leased mines over a period of 17 years.

1. Mines Monitoring Tools

The Mines Monitoring Tools is adopted to aid regulatory functions of the DGM for proper inspection and monitoring of all mining activities in the country and to improve the overall compliance to the provisions of relevant Acts, Regulations, Final Mine Feasibility Study (FMFS) reports and terms and conditions of the Mining Lease Agreement (MLA), permits and clearances. The tools are implemented through regular and timely inspections of the mines, highways and other areas and specific inspections as and when required or as directed by the Head of the DGM. This tool is used for the following purposes;

i. To provide objective compliance monitoring and facilitate promotion of enforcement culture by both the lessee and the regulating agency;
ii. Facilitate in objective Performance Evaluation of the mines with documentation;
iii. To reduce the administrative burden and the frequency of inspection through building a reliable database.

2. Performance Evaluation of Mines & Quarries

The Ministry has amended MMMR 2002 with an objective to adopt performance evaluation of mines. The rating scheme is designed to have a built-in compliance mechanism for environment and mine operations and

OHS safeguards and will help in recognizing good performers in the sector while encouraging all mining lease holders to strive for excellence.

Some of the areas of parameters considered for ratings are mine operation, environmental management, occupational health & safety, mine reclamations or restoration, CSR activities, skill development, innovation and any non-compliance notices issued to the lessee. Such ratings are given out of 100% categorizing the ratings into 5 categories. The scores shall determine the eligibility for obtaining new mining and renewal license. The Regional Offices of the DGM carries out the rating biannually while Head Office rates on annual basis. Based on the aggregated scores, the mines are rated as shown in the Table 1.

Table 1. Performance rating categories.

Ratings	Score (%)
Outstanding	80 % and above
Very good	70 to 79
Good	60 to 69
Average	50 to 59
Below Average	Below 50 %

3. Mine Restoration Guidelines (MRG)

The Mine Restoration Guidelines is a guiding document to ensure successful restoration of mines in the country. The following benefits are envisaged from the implementation of this guideline to;

a. guide preparation of the Mines Restoration Plan;

b. specify the restoration procedures and requirements;

c. assist in the compliance monitoring and reporting requirements; and

d. provide a clear timeline for restoration and mine closure.

4. Guidelines for Surface Collection of Minerals 2020

With increasing application for Surface Collection of minerals, the Guidelines for Surface Collection of Minerals 2020 is adopted to support the provisions of MMMA 1995 and MMMR 2002.

This guideline outlines the application processes, documents requirement, standards of surface collections and monitoring of the surface collection activities.

5. Ad Valorem Royalty System

To ensure that the government receives fair share of tax revenue from sale of minerals, the Ad Valorem Royalty System was first introduced in 2016 for export of minerals through enactment of The Revised Taxes and Levies Act 2016.

The Ad Valorem system of levying royalty on minerals is being introduced for the first time in the Country and is applicable to export of minerals only. It was introduced to have adequate mineral levies established proportionate to the mineral value and to incentivize domestic use and encourage in-country value addition.

The ensure that the sector is not affected by undervaluation of minerals, a Minimum Floor Price (MFP) was introduced which is reviewed and revised on annual basis by the DGM. The mode of collection is based on the following formal;

Royalty = *((Sale price of mineral* ***X*** *Rate of royalty in Percentage (%)) + (Amount equivalent to 10% of calculated export royalty)* ***X*** *Total quantity of mineral dispatched or exported))*.

6. Mines & Minerals Bill 2020

To align with the objectives of MDP 2017 and other reforms, MM Bill 2020 is deliberated in the Parliament. The MM Bill envisages to promote good governance, sustainable mining practices, environmental stewardship, improve benefits to nation and affected communities.

Conclusion

The reforms undertaken would resolve contemporary issues in mining sector & improve the benefits to the nation. It may, require periodic reviews and revisions in keeping with the changes with both domestic and international mining scenarios and best practices. The reforms shall also guide regulatory agencies, lessee and prospective investors in the mining sector.

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A REVIEW OF SUSTAINABLE MINING BUSINESS IN BHUTAN

Nima Yoezar[1]

Abstract

Striking balance between the impact of mining on economy and social environment has always been a challenge and has come to limelight of the public in recent years. Using the Mixed Method Concurrent Triangulation Strategy to determine the perception on (1) impacts of mining on environment; and (2) sustainable use of minerals, the survey findings (N=122) indicate that there is a need to adopt more innovative approaches to environmental regulation and promote broad-based ownership. In addition, the respondents also rated on the need for value chain creation and mandatory enforcement of regulatory provisions to maximize the benefits of mining to larger population. The study also suggests to channelize the transport of minerals through single unit and introduce higher surface rents for those mining areas that exceeds 25 acres of land.

Introduction

The study carried out Shields and Solar (2006) revels that attitude within the mineral sector have evolved over the time. In the beginning, the focus was on discovery and access of minerals. By late 1900's, environment gained priority due to potential adverse impact on mining.

With the emergence of sustainability paradigm, the need to consult and engage community about business activities have taken the center stage. In the recent times, ensuring the benefits of mining with the current and future generation is debated and discussed (Figure 1). The promotion sustainable development without addressing all those concerns or issues is essential to realize net benefits to the society. Though mineral sector in Bhutan is development stage, all the issues are relevant.

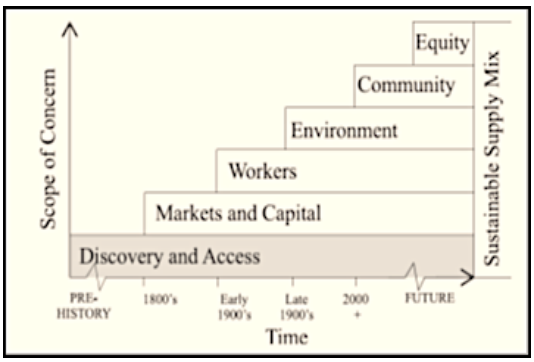

Figure 1. Expansion of scope of concern about mineral supply (Shields and Solar, 2006).

The Economic Development Policy (2016) has identified mining sector as one of the five economic jewel due to its

[1] Nima Yoezar, Senior Program Officer, Department of Geology and Mines; Post Graduate Diploma in Public Administration, RIM; Post Graduate Certificate in Corruption Studies, HKUSPACE, Hongkong.

potential to accelerate the country's economy. So far Bhutan has not been able to maximize the benefits from mining. In 2019, mining and quarrying sector has contributed only 4.81 percent to GDP. The challenge of not being able to reap the benefits from mining are multi-folds. The Anti-Corruption Commission Report (2016) has identified poor governance, insufficient investments and corruption as a major concern for not being able to share the benefits from mining to the broader society.

Furthermore, the Royal Audit Authority Report (2014) has also observed inadequacies in the legal, institutional and regulatory framework, and lack of anti-trust laws to protect the minority investors as an inherent problem in the mining sector. The prevalence of such practices has affected the business culture and also undermined the larger interest of the society in terms of wealth distribution, inter-generational equity and sustainable use of natural resources of the country.

This study attempts to find perception on current mining governance and provide recommendations to improve mining environment using nine structured questionnaires on environment, sustainable management, revenue collection, women leadership and broad-based ownership governing mining operations.

Methodology

This study used both qualitative and quantitative methods. The data collected were analyzed using XLSTAT to generate descriptive or explanatory information for interpretation. The work flow is provided is Figure 20.

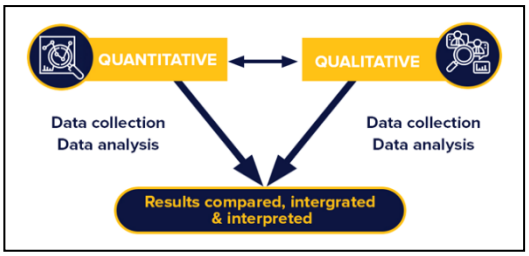

Figure 2. A Visual Diagram of the Mixed-Methods Concurrent Triangulation Strategy. Source: Creswell and Clark (2007).

To avoid skewing of data and results, the purposive sampling technique was adopted and structured questionnaires were floated to targeted respondents (N=180) such as politicians (N=48), mine promoters and consultants (N=21), researchers, academician, journalists, bureaucrats and the general public (N=111). The survey sample size was determined considering 90% confidence level to attend the survey by the respondents. The response rate was 67% (N=121). The details on survey questionnaires are provided under Results and Discussion section.

Results and Discussion

1. How could Bhutan minimize environmental impacts resulting from the mining activity?

Figure 3 shows the response pattern to minimize environmental impacts resulting from the mining activity.

The findings of this study suggest to adopt innovative approaches to environmental regulation to minimize the impact of mining on environment as 34% of respondents have preferred it, whereas, 23% of respondents who has proposed to establish stringent laws and regulations to prevent environmental legacies and public costs on exhaustion of mineral extraction.

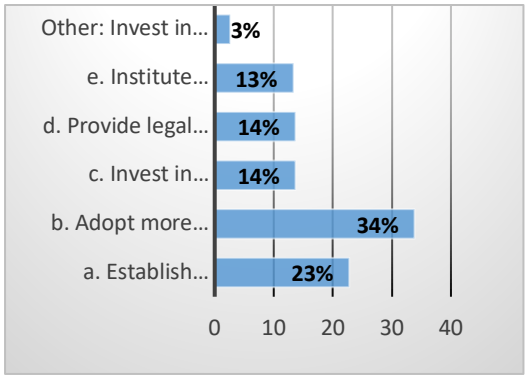

Figure 3. Measures to minimize environmental impacts resulting from mining activity.

The pattern of response suggests for reforms in mining and environment policies to promote use of greener technologies and adoption performance-based incentives. It also emphasized strict compliance of the regulations.

2. How could Bhutan use minerals more sustainably to ensure intergenerational equity?

From a total of 121 respondents, 22% prefers to recycle and reuse minerals for sustainable material management (Figure 4).

It is followed by 21% of respondents who desires to establish Mineral Endowment Fund. Only 17% of the respondents has expressed to limit the issuance of mining license to maximum of one per individual or a company at any given instant. To regulate the issuance of only one mining licence to the mineral-based industry is least preferred by respondents. The study result suggests the government to adopt above combined methods to ensure intergenerational equity.

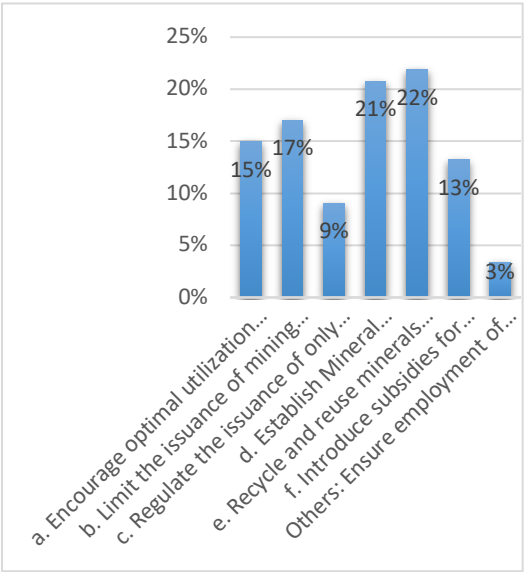

Figure 4. Sustainable use of minerals.

3. What measures have to be implemented to draw a fair share of revenue by the government and realize the benefits from mining?

Under this category, 32% of the respondents prefers to introduce the

profit-based royalty assessment, while 28% of respondents opted to implement unit based royalty system for high volume, low value homogenous minerals (quartzite) and Ad Valorem royalty system for other minerals; Only 23% of respondents prefers the current system of Ad Valorem royalty.

The study encourages to introduce profit based royalty assessment. Such royalty systems are prevalent mostly in developed countries (Indian Bureau of Mines, India p.18, 2011).

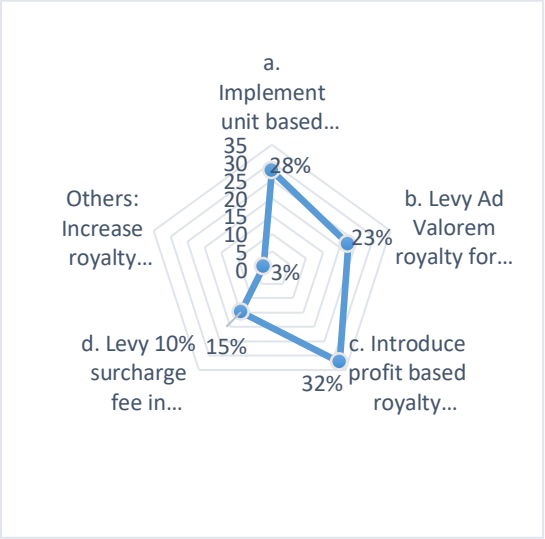

Figure 5. Fair share of revenue collection from mining.

Such scheme would ensure fair share of revenue to the government when the mining companies makes super profits. It will help the company without having to pay the royalty while they are in loss but government may lose steady flow of tax revenue from royalty. However, adoption of such system would require higher standards of integrity and proper accounting system in place to assess the value at the end.

4. How could Bhutan promote women's leadership in the extractive industry?

As per the survey findings, highest proportion of the respondents (33%) have suggested to encourage mining companies to implement women-specific policies to empower and protect women in the workplace, while 30% of respondents have indicated to support career advancement for women in C-suite executives or management cadre (Table 1).

Table 1. Women leadership in extractive industry.

Response options	Response
a. Include a policy to replace a woman employee with another woman in addition to new recruitment through open competition for other positions;	19%
b. Prescribe laws for companies to spend no less than 3 to 5% of their annual payroll on human resource development, focusing especially on women.	15%
c. Promote career advancement for women in C-suite executives/management cadre and impart skills to progress up the employment hierarchy;	30%
d. Encourage mining companies to implement women-specific policies to empower and protect women in the workplace;	33%
Others: I am not sure; Gender is not an issue; Preference could be given to women during recruitment.	3%

Only 19% of the respondents stated to include a policy to replace a woman

employee with another woman in addition to new recruitment through open competition for other positions.

The study suggests to create enabling environment for women and child at work places to promote women participation in the mining companies. Further, the findings also reveal that mining companies should prioritize skill development of women employees to equip them with required expertise to progress in their career ladder.

5. How could Bhutan strategize to promote broad-based ownership in mining activity?

More than half of the respondents (62%) has submitted their views to enforce all large mines to mandatorily offer initial public offerings (IPO) of 60 to 70%; Medium mines to offer at least 49%; and Small mines or quarries to float at least 15% respectively to promote broad based ownership; On the other hand, 21 respondents out of 121 have opted to mandatorily officer IPOs of large mines at least 49%; medium mines and small mines up to 30% and 10% respectively (Figure 6).

The overall finding suggests to increase the in IPO for all categories of mines. This will require revision of the current legal provisions to require the mining companies to float shares for ensuring broad-based ownership in management of natural resources.

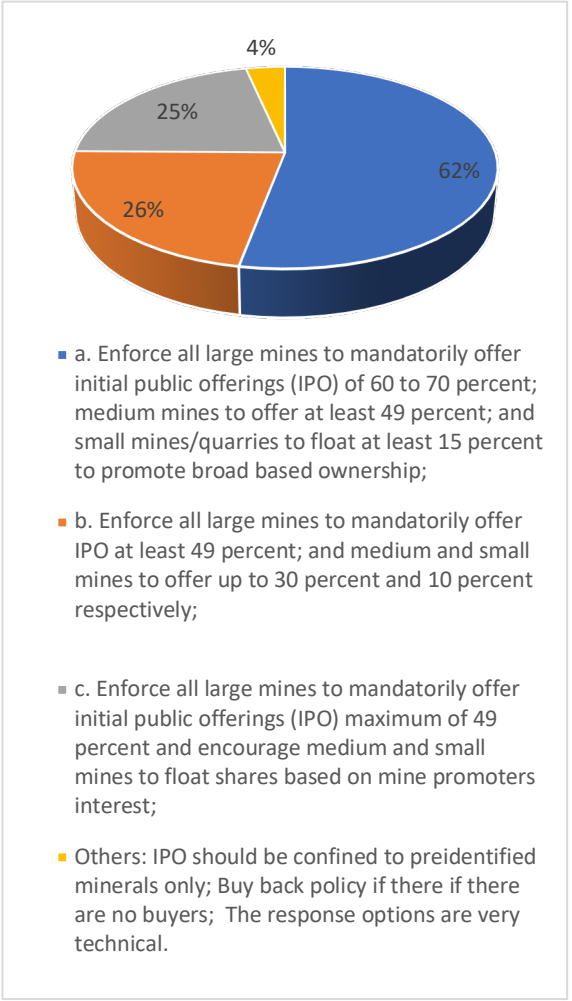

Figure 6. Promotion of broad-based ownership.

6. What kind of regulatory provisions should be adopted to promote minority investors in mining companies?

Creation of subsidiary companies by public companies are detrimental to the interest of the minority shareholders and the government as it marginalizes the interest of minority shareholders (RAA, 2014). The details of responses are presented in Table 2.

Table 2: Minority shareholding pattern.

Options	% of respondent
a. Enforce all auctioned mines to maintain minority shareholding pattern (e.g. at least 30% shareholding of minority investors in any business undertaking) throughout the auction period;	40%
b. Allow every majority shareholders (promoters) of the company to own up to 10% of shares in the subsidiary company;	22%
c. Restrict the formation of subsidiary companies if the combined shares of major promoters are more than 30% in the subsidiary company;	52%
Others: Stronger protection of minority shareholders provisions in the Companies Act. May depend on case to case; No idea	4%

The results of this study indicates that the most effective measure to protect the minority shareholder is to restrict the formation of subsidiary companies.

7. How Bhutan could strategize to maximize the utilization of mineral resources to accrue maximum benefit amid increasing invention of synthetic minerals substitutes.

More than half of the respondents (55.5%) favored to enforce establishment of value addition plants for those mineral which are techno-economically viable for value-chain creation (Figure 7); About 22.7% of respondents suggested to auction the mineral deposits which are abundantly available in the country without any conditions.

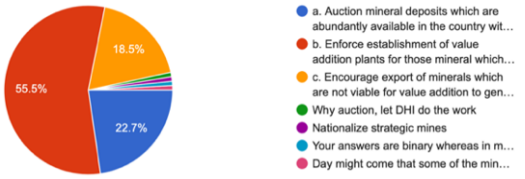

Figure 7: Maximization of mineral resource utilization.

The findings indicates that minerals being as a common resource, there are concerns on the sustainable use and equal distribution of the benefits. The findings supports the policy provision of Mineral Development Policy 2017 to encourage in-country value addition for all viable minerals and curtail export of minerals in raw form.

8. How could Bhutan strategize to accrue the actual amount of royalty for export of minerals?

The Figure 8 shows the survey data on measures to realize accrual value of minerals to maximize the benefits. From a total of 121 respondents, 48% has selected to channelize the transport any minerals through a single unit or company from country exit point till mineral based industry while 43% chosen to tender out transportation of minerals to one of the transportation sector for a period of 3 to 5 years to determine the actual value of minerals and re-tender it on regular intervals. Only 21% respondent (N=25) has opined

to tender out transportation of minerals to one of the transportation sector to transport the minerals to mineral based industry for entire period auction period;

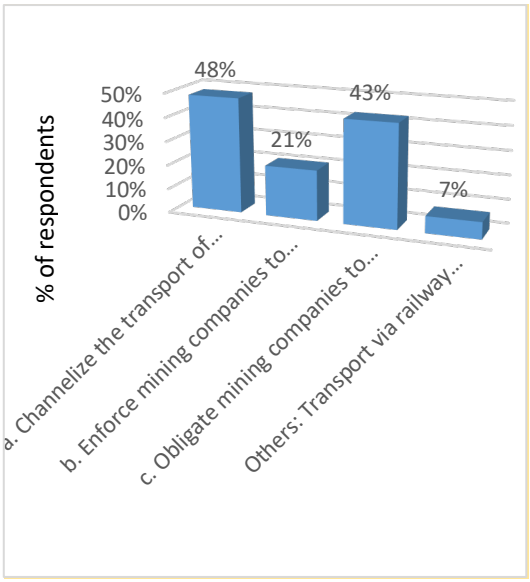

Figure 8. Measures to realize actual value of minerals.

The Survey suggest that canalization is the most effective means to realize higher value of minerals. Further, selection of transporter through an open competitive bidding would also promote transparency in the rates of minerals to realize the actual value of mineral.

This findings reinforces to implement the provision of Economic Development Policy 2016 which states “Export of minerals or construction materials in raw form shall be canalized through authorized agencies to maximize the returns from exports and discourage primary exports."

9. In order to promote sustainable land use management for mining activity, what kind of regulatory provisions must be adopted by the Government?

From the survey, 45% of respondents have preferred to introduce higher Surface Rent for those mining areas that exceeds 25 acres of State Reserve Forest (SRF) land or State land (Figure 9). On the other hand, 29% of respondents have also suggested to levy Dead Rent in addition to Surface Rent for those mining areas in case mine promoters does not commence mining activity within first 2 years from the issuance of Land Lease Certificate. Least numbers of respondents (5%) have opted to escalate Surface Rent for non-operational mines on annual basis.

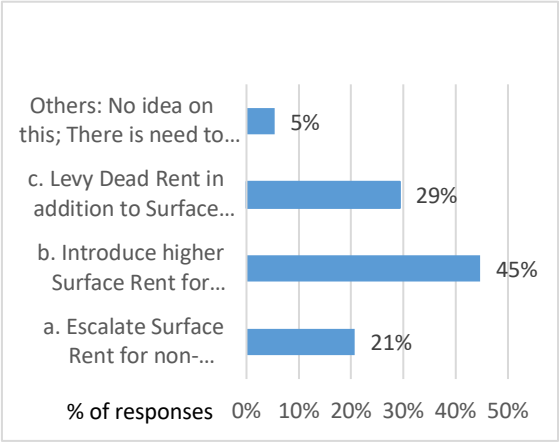

Figure 9. Sustainable management of land.

The survey data supports the revision of the Surface Rent to discourage unnecessary landholding by increasing rates.

Limitation of the study

Due to limited information on (1) impacts of mining on environment; and (2) sustainable use of minerals in Bhutan, it is beyond the scope of this paper to provide an in-depth study. Due to a lack similar study being under taken, the current study couldn't make comparative studies. Therefore, literatures from international sources were referred to formulate questionnaires and draw association in the Bhutanese context.

The study initially planned to be completed in three months was fast-tracked within a month due to urgency to complete it in this financial year. This has led to reduction of duration to administer survey and the study could account only 67% of responses deviating from the initial expected target of 90%. Due to small size of survey samples, it may not directly represent the views of the larger population.

Conclusion

Sustainable development of mining is essential as it forms the material basis of existence. The Royal Government emphasizes on middle path development strategy and GNH philosophy, and its already making concerted efforts towards meeting sustainable development goals. From the survey data, it may be concluded that the Royal Government needs to further prioritise the following to further reinforce the efforts towards sustainable mining;

1. Incentivize to promote use of green technologies in mining and value addition of minerals;
2. The intergenerational equity may be ensured through optimal utilization of minerals and establishment of mineral endowment fund among others;
3. Promote broad-based ownership through revision of legal frameworks to share the benefits of mining by general public;

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OHS IN SURFACE MINING - PREVENTION MEASURES FOR WORK RELATED ACCIDENTS

Pratik Bhattarai[1]

What is Occupational Health and Safety (OHS)?

According to the World Health Organization (WHO) and the International Labour Organization (ILO), "Occupational Health Safety (OHS) is the promotion and the maintenance of highest degree of physical, mental and social wellbeing of the works in all occupations; the prevention of workers of departures from health caused by their working conditions; the protection of the workers in their employment from risks resulting from factors adverse to health; the placing and the maintenance of the worker in an occupational environment adapted to its physiological and psychological capabilities."

OHS is the responsibility of the Government in regulation, the employers to provide safe working environment for all the employees and their duties to comply with the OHS guidelines.

OHS from an International Perspective

The ILO's Convention on Safety and Health in Mines, 1995 (No. 176) covers the coal mines. It provides floor – the minimum safety requirements against which all changes to all the mine operations should be measured. The accompanying Recommendation (No.183) which is an advisory, provides more specific guidance on different sections of the convention. the Convention sets out procedures for reporting and investigating accidents and dangerous occurrences in mines. The government that ratifies it undertakes to adopt legislation for its implementation including the designation of the competent authority to monitor and regulate the various aspects of safety in mines.

OHS Legislative Framework

The Constitution of the Kingdom of Bhutan entrusts the state to assume responsibility for the protection of the labour force. Chapter IX of the Labour and Employment Act 2007 is devoted to the health and safety which includes various sections concerning health and safety that apply to all types of employment, except farming (MoLHR, 2012).

For mining sector, there is a separate coverage on requirement of OHS in the mines as per the Mines and Minerals

[1] Pratik Bhattarai, Mining Engineer, Department of Geology and Mines, B.E. Mining Engineering, Acharya Institute of Technology, India. Email: pbhattarai@gmail.com

Management Act, 1995 and its Regulations, 2002. Under the act, the lessees are responsible to ensure a safe and healthy working environment. They should report any workplace accident to the Ministry. The Ministry is also empowered to frame regulations and standards on health and safety of the workers in keeping with the view of national legislation on OHS related to mines.

OHS in Bhutan

The Ministry of Labour and Human Resources (MoLHR) is the lead government organization in OHS. It deals with different aspects of OHS, in particular prevention, enforcement and compensation. The Ministry of Health (MoH), The Ministry of Economic Affairs (MoEA), The Road Safety and Transport Authority, Ministry of Agriculture and Forest and National Environment Commission plays major preventive role compared to other organizations in OHS. The MoH shoulders the roles and functions in OHS by providing occupational health services in all sectors through its hospitals, BHU, outreach clinics and health care network system. (MoLHR, 2012). The Department of Geology and Mines (DGM) under MoEA enforce laws in occupational health and safety in the mining industries.

The probability of fatality in the construction industry is five times more likely than in the manufacturing industry in Bhutan. The scenario in Bhutan is same as in other developing countries. The construction industry contributes about 60% of work place accidents compared to manufacturing i.e., 33%, mining and quarrying which is 5% and finally trading and services sector which is 2% (Drukpa and Dendup, 2017).

Failure to comply OHS has contributed to poor safety practices in the country. About 60 work place accidents were reported from 2015-2016 to the Ministry of Labour and Human Resources (Table 1). During the period one fatal and two partial disability cases have been reported from the mining and quarrying sector.

Table 1: Sector wise work place accident 2015-2016; Source: Department of Labour, 2017

Sector	Fatal	Total Disability	Partial Disability	Total
Construction	4	0	1	5
Hydropower Construction	17	3	11	31
Manufacturing and Production	1	1	18	20
Mining and Quarry	1	0	2	3
Trading and Services	1	0	0	1

Mines and quarries with hazards have potential to impact the health of the workers and visitors. The main contributing factors include mechanical failure, inadequate training or human error. Generation of suspended dust particulate to the workers along the crushing units without proper safety gears or suppression methods could lead

to fatal illnesses in the long run to the workers.

Hierarchy of Safety Controls

The hierarchy of safety control is implemented to minimize or eliminate hazard and health risks and help provide workers with safe and healthy working conditions. Controlling exposures to occupational hazards is the fundamental method of protecting workers. Traditionally, a hierarchy of controls has been used as a means of determining how to implement feasible and effective control solutions (NIOSH, 2015).

The most common representation of this hierarchy is as follow:

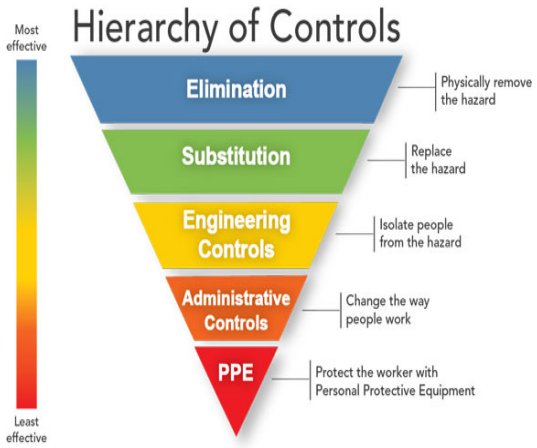

Figure 1: Hierarchy of Controls, Source: National Institute for Occupational Safety and Health National Institute for Occupational Safety and Health, 2015.

The idea behind this hierarchy is that the control methods at the top of the image are potentially more effective and protective than those at the bottom. Following this hierarchy normally leads to the implementation of inherently safer systems, where the risks of illnesses or injuries have been substantially reduced.

1. Elimination and Substitution

Elimination and substitution are the most effective measures as they mitigate the hazard but are the most difficult to implement. If the process is still at the design or development stage, elimination and substitution of hazards may be inexpensive and simple to implement. For an existing process, major changes in equipment and procedures may be required to eliminate or substitute for a hazard.

This control measure entails removing hazards immediately or substituting it with a hazard with lesser risk such as:

- Wet suppression technology can be adopted in the crusher to eliminate dust at its point of generation;
- Working near conveyors and moving machinery to be avoided as much as possible;
- Machinery to be used instead of manual workers in operations such as excavation, hauling and loading;
- Controlling the risk of rock falls during initial stages of excavation by maintaining proper slope angles.

2. Engineering Controls

Engineering controls are favoured for controlling existing worker exposures in the workplace because they are designed to remove the hazard at the source before it comes in contact with the worker. Well-designed engineering controls can be highly effective in protecting the

workers and will typically be independent of worker interactions to provide this high level of protection. The initial cost of engineering controls can be higher than the cost of administrative controls or personal protective equipment (PPE) but over the longer term, operating costs are frequently lower, and in some instances, can provide a cost savings in other areas of the process.

The following engineering control measures can be implemented to reduce worker exposure to pollutants and danger;

- Periodic water sprinkling carried out along the haul roads, quarry/mine area, overburden dump yards and crushing plant areas to control airborne particulate matter or dust that could cause serious respiratory diseases such as silicosis, asbestosis, occupational lung disease, etc.;
- Dust guard installation in most moving machineries such as covered crusher conveyors, enclosed cabins in haulers, plant and equipment;
- A worker engaged in loading, unloading, or conveying explosives must be trained in the proper means for handling the explosives;
- Safe bench parameters are to be maintained based on the geotechnical characteristics of the rock strata, excavation method and the equipment reach.

3. Administrative Controls and PPE

Administrative controls and PPE are frequently used with existing processes where hazards are not particularly well controlled. These methods for protecting workers have also proven to be less effective than other measures, requiring significant effort by the affected workers. Examples of administrative controls shall include the following;

- Safety signs to be properly displayed at the entrance and exit points of a quarry/mine. Other signs such as speed signs and hazard signs are required to be erected to caution operators to minimize accident risks, and also reduce dust generation;
- Regular maintenance of machineries to mitigate noxious gases emission such as CO, CO_2, SO_2, etc.;
- Adequate training and information on safe working method and restricting them from wearing loose clothing when working near moving machineries;
- The duration of working exposure to be limited through worker rotation especially in the maximum dust and noise generating areas;
- Transportation facilities to be immediately provided to the workers to the nearest hospital or BHU in the event of medical emergencies at the site;

- Basic first aid kit shall be made available at the working sites at all times.

PPE such as safety helmets, safety boots, safety googles, gloves, earplugs, dust mask and first aid kits should be made available to all the workers and visitors at the site by the lessee.

Duties of Employee and Lessee

Ensuring safety at mine sites requires concerted effort of workers and the management. Some of the duties of the lessee are:

1. Provide adequate PPE to workers and facilities at the mine sites;
2. Ensure workers understand the safety and health protocol through training and workshops;
3. Appoint one or more safety officer/supervisor to supervise and control operation at mine;
4. Ensure new recruits to receive instructions and on-the-job trainings on OHS before employing at the site;

Some of the duties of the workers are:

1. To take care of the health and safety of himself and other persons who may be affected by his acts or omissions;
2. To comply with instructions for his own safety and of the others;
3. To use PPE in accordance with the instructions that has been given;
4. To report any situation which he may consider as hazardous /to his immediate supervisor;
5. To report any accident and injury which arises at the work place;

Mining accidents and dangerous occurrences

Mining accident means any occupational injury to any person as a result of mining work within the area of mining activity, for which medical treatment is administered or which results in loss of consciousness or death. Dangerous occurrence means any unplanned event at any mine that has the potential to cause an injury or disease to persons at work. A dangerous occurrence could be an event that:

- Substantially affects regular mining activity, such as landslides, collapse of the working face, major rock falls, inrush of water into the mine, the unintentional ignition or detonation of explosives;
- Causes damage to or disrupts the operation of any vital mining machinery or equipment, such as explosion, fire or bursting of a pressure vessel;
- Requires the withdrawal of miners or any other emergency action;
- Endangers any individual at the mine.

At any mine where an accident or dangerous occurrence takes place, the lessee should ensure that:

- The necessary steps are taken to evacuate and treat injured workers

and immediate action is taken to prevent further danger arising from the event;
- An investigation into the cause of the accident or dangerous occurrence is carried out and preventive action is taken to avoid similar events in the future;
- The result of the investigation is shared to relevant authorities;

After a mining accident or dangerous occurrence, the lessee should ensure that practices are improved which would prevent it from happening again.

Hazards at working environment

In the working environment of a surface mine, airborne contaminants (such as rock dust and fumes), excessive noise, vibration, heat stress and ergonomic problems can create health risks to mineworkers who are subjected to frequent and prolonged exposure to them.

Dust

Airborne contaminants, such as dust, are mainly produced during drilling operations, excavation, loading, crushing of rock or ore, and blasting. Persons exposed to excessive dust for prolonged periods may suffer from permanent lung diseases, such as silicosis.

Efforts to control escape of dust into the atmosphere should be implemented. Dust should be controlled or suppressed by:

- wet drilling and dust suction techniques;
- water sprays during mineral extraction, loading, crushing, haul roads, etc.

Where such dust control measures are not provided or have not been developed, mineworkers exposed to excessive dust concentration in their working environment should always use PPE such as dust masks to prevent dust from being inhaled.

Harmful fumes

Fumes, produced during blasting operations contain toxic gases (such as SO_2, NO, NO_2, CO, CO_2, etc.), which when inhaled, can lead to serious health issues. The site supervisor must ensure that the miners do not enter the mines site until the dust and gaseous products of the blast have completely settled and dissipated. The exhaust from diesel engines also contain harmful fumes, including very fine, respirable particles. Frequent and prolonged exposure to diesel exhaust is a health risk and should be prevented.

Noise

Repeated or prolonged exposure to excessive noise levels will lead to hearing impairment. Potential sources of noise emissions include compressors, drilling machines or other mechanical equipment used at a mine. Wherever possible, such noise sources should be muffled with an effective acoustic

absorbing material so as to reduce noise emissions to tolerable levels.

Increasing the distance between the noise source and the workers is often a practical method of noise control. Where such noise control measures are not possible, PPE such as approved ear plugs or ear muffs should be worn by every person exposed to noise levels exceeding 90 dBs. Rotation of workers or operators must be done to prevent prolonged exposure to noise.

Vibration

Workers operating hand-held machinery, such as pneumatic rock drills and jack hammers even for an hour a day can suffer from the effects of vibration in their hands and arms. Vibration White Finger (VWF) or "dead finger" starts when the fingers become numb. Vibration White Finger can lead to gangrene and there is no cure for it. Therefore, following measures are recommended:

- Avoid long periods using equipment. (Work in short bursts);
- Use modern, vibration-dampened equipment;
- Repair or replace old equipment or fit anti-vibration handles;
- Grip handles as lightly as possible;
- Support heavy tools so that a lighter grip can be used.

Heat stress

In Bhutan as most of the mining sites lie along the slope face and receives direct sunlight most of the time, heat stresses are prevalent along all the sites.

To avoid heat stress, following measures are recommended:

- Awareness on heat stress and use of protective measures;
- Ensuring access to safe drinking water to keep hydrated;
- Shade (e.g., canopy) to prevent excessive exposure to heat;

Ergonomics

Many aspects of mining work carry risk of injury to the upper and lower limbs or spine, either because of the manual handling tasks involved or because of awkward postures. Basic ergonomic requirements should be considered, including workplace layout, design of equipment and tools, working techniques, working time and rest patterns. Training on proper positioning the body in the mine environment should be implemented to avoid injuries.

Health and Welfare of Employees

The lessee should provide facilities to ensure basic health sanitation of all the workers. The lessee should also ensure periodic checkups of the workers.

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MINING SECTOR AT A GLANCE

Sangay Dendup[1]

Mining in Bhutan

The mining sector has been identified as one of the five jewels of economy of the country due to its potential for economic growth and diversification. The Mines and Mineral Management Act (MMMA) 1995 and Mines and Mineral Management Regulations (MMMR) 2002 (amended) provides guidance to the sector to ensure scientific management of mineral resources and maximize the benefit to the nation and community. Further, the Economic Development Policy (EDP) 2016 and Mineral Development Policy (MDP) 2017 provides policy direction to the sector.

Given the rugged topography of the country, mining in Bhutan is limited to open cast mining. In this context, the commonly adopted mining method drilling and blasting for extraction of minerals, while excavator-truck combination is used for loading and transportation of minerals and wastes.

Current Mining Scenario

Currently, there are total of 31 active mines and 50 stone quarries in the country, which accounts for only 0.04% of country's area. However, 4 mines and 12 stone quarries are non-operational due to market issues and few quarries have been recently leased. The regional distribution of the mines and quarries is shown in Figure 1.

Further, there are total of 27 permit holders for collection of minerals from the riverbeds and surface (mostly land developemnt). Four different types of minerals collected under the permit of Department of Geology and Mines (DGM) is as shown in the Figure 2.

Some of the minerals mined in Bhutan are gypsum, dolomite, quartzite, talc, limestone, marble, coal, iron ore, calc tufa, phyllite and construction stones. Table 1 shows distribution of mines and quarries in each Dzongkhag. The allocation of mines generally follows first-come, first-serve principle while government also allocate mines through public auctions of those minerals deposits which are explored and proven under public funding.

Dolomite mine in Chunaikhola, Gypsum mine in Khothakpa and Coal mines in the Eastern Bhutan are three large scale mines in Bhutan. These

[1] Sangay Dendup, Mining Engineer, Department of Geology and Mines, MoEA, Thimphu, Bhutan
B.E. Mining Engineering, Acharya Institute of Technology, India. Email: sangaydendup@moea.gov.bt

mines were auctioned for a period of 15 years. However, upon completion of auction periods, these mines are operated by State Mining Corporation Limited (SMCL) for interim period.

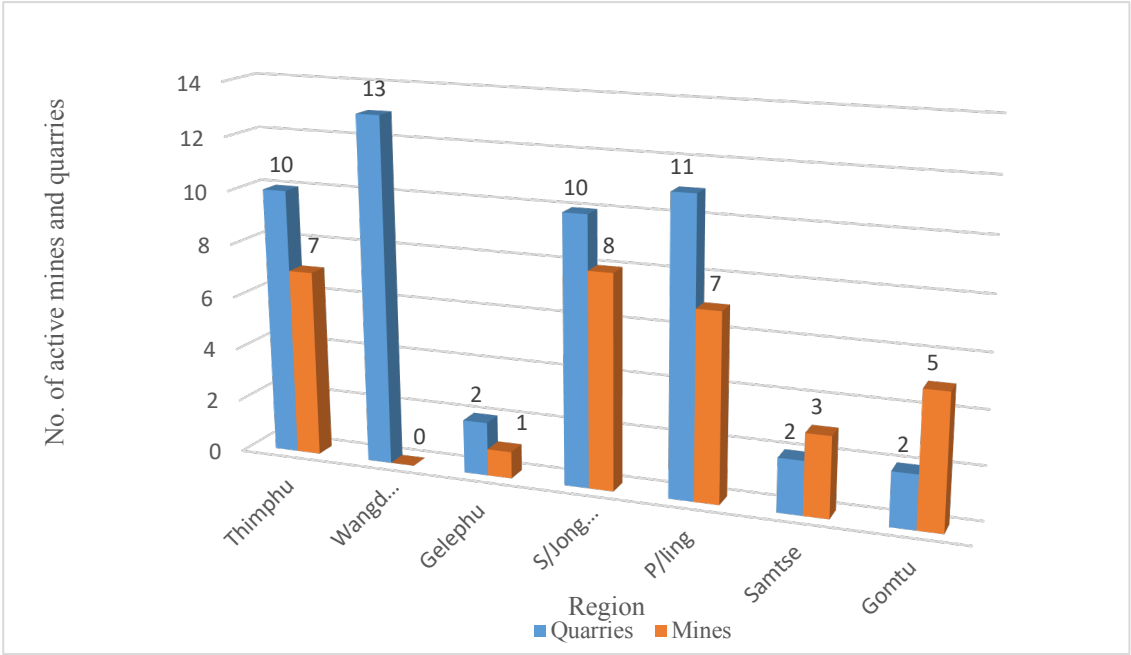


Figure 1. No. of active mines and quarries based on the Regions

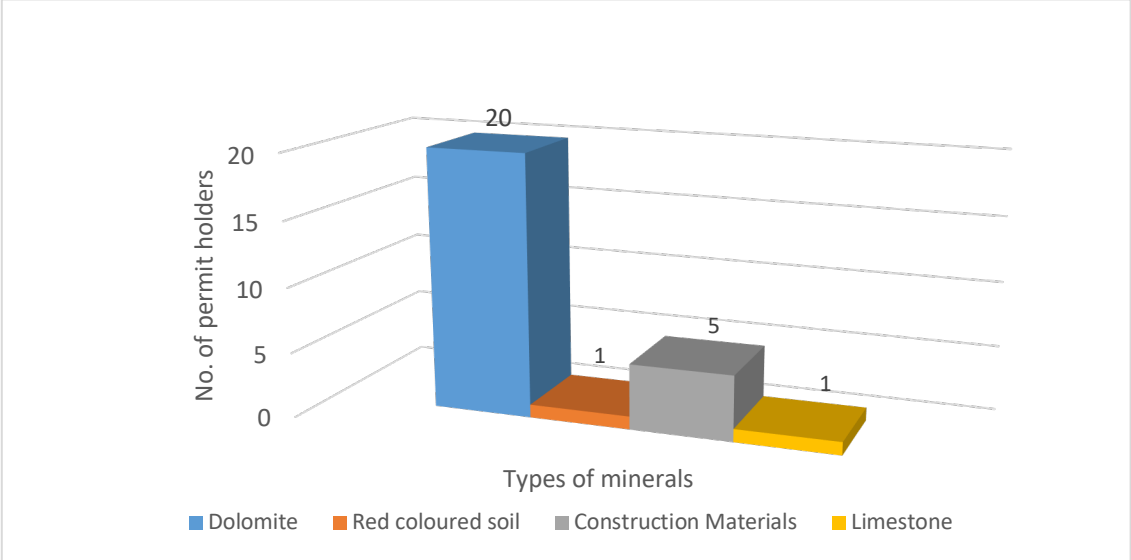


Figure 2. No. of permit holders

Table 1. Dzongkhag wise distribution of mines and quarries

Types of minerals													
Dzongkhag	Calc Tufa	Coal	Construction stone	Dolomite	Granite	Gypsum	Limestone	Marble	Iron Ore	Phyllite	Quartzite	Talc	Total No.
Bumthang			2										2
Chukha			5								4	1	10
Dagana			3						1		1		5
Gasa													0
Haa													0
Lhuentse													0
Mongar			3										3
Paro			5				1						6
P/Gatshel			3			2	2						7
Punakha													0
S/Jongkhar		4											4
Samtse	1		10	1			3				4		19
Sarpang													0
Tashigang			2										2
T/yangtse			1										1
Thimphu			4				1	2					7
Trongsa			1								1		2
Tsirang													0
Wangdue			10		1								11
Zhemgang			1										1
Total													**81**

Revenue contribution from Mining

Mining sector is the backbone of economic development. The economic growth of any nation is primarily driven by its richness in mineral resources and mining (e.g. Australia, Canada, Middle east countries, Mongolia, South Africa, US, etc.). It not only provides raw materials for industrial development, but it is also one of the main sources of foreign exchange through sale of minerals and its products.

The mineral wise production for the last five years (2015-2019) is shown in Table 2. The quantity of the mineral sale in domestic and export market in 2019 and 2020 is as shown in Figure 3 and Figure 4, respectively. Revenue from mining is generated in the form of royalty, mineral rent, land lease rent, auction fees (license), Corporate Income Tax, Business Income Tax and other forms of taxes. Its contribution has been increasing over the period. Royalty contribution (both domestic and export) in 2019 is shown in Figure 5. In 2018-19, the revenue contribution from royalty and mineral is Nu. 456.7 million. This sector is reported as top ten major revenue contributors in 2017-18 as shown Figure 6.

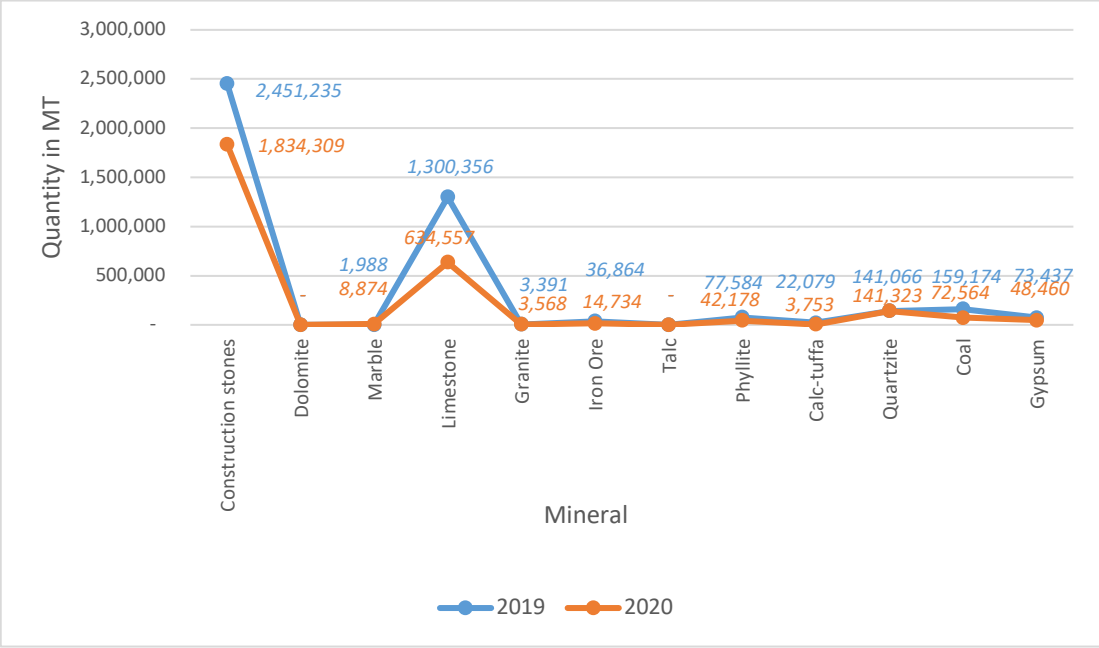


Figure 3: Sale of minerals in domestic market in 2019 & 2020

Table 2. Mineral production for the last five years

Sl. No	Mineral in MT	Year					Total
		2015	2016	2017	2018	2019	
1	Calc Tufa				12,323.80	22,079.10	34,402.90
2	Coal	85,164.45	117,783.00	161,526.74	186,823.75	184,784.50	736,082.44
3	Construction stones	2,203,065.41	3,414,215.00	3,828,254.00	3,730,975.36	3,325,418.60	16,501,928.37
4	Dolomite	2,662,309.68	2,367,659.00	2,536,693.31	2,821,116.44	3,027,517.70	13,415,296.13
5	Granite	3,889.05		26,364.04	6,293.33	3,391.30	39,937.72
6	Gypsum	389,364.80	317,597.00	328,127.99	461,128.12	490,595.50	1,986,813.41
7	Iron ore	43,201.96	28,065.00	32,974.37	37,843.08	36,864.20	178,948.61
8	Limestone	850,431.17	1,257,101.00	1,235,161.67	1,344,037.86	1,546,302.10	6,233,033.80
9	Marble	97,647.84	75,031.00	96,567.10	188,900.53	94,318.30	552,464.77
10	Phyllite	40,417.25	41,800.00	61,910.29	53,188.53	78,246.40	275,562.47
11	Quartzite	79,818.50	92,770.00	175,501.08	145,713.93	141,065.90	634,869.41
12	Talc	5,807.27	2,261.00	1,293.20	2,042.46	1,374.80	12,778.73

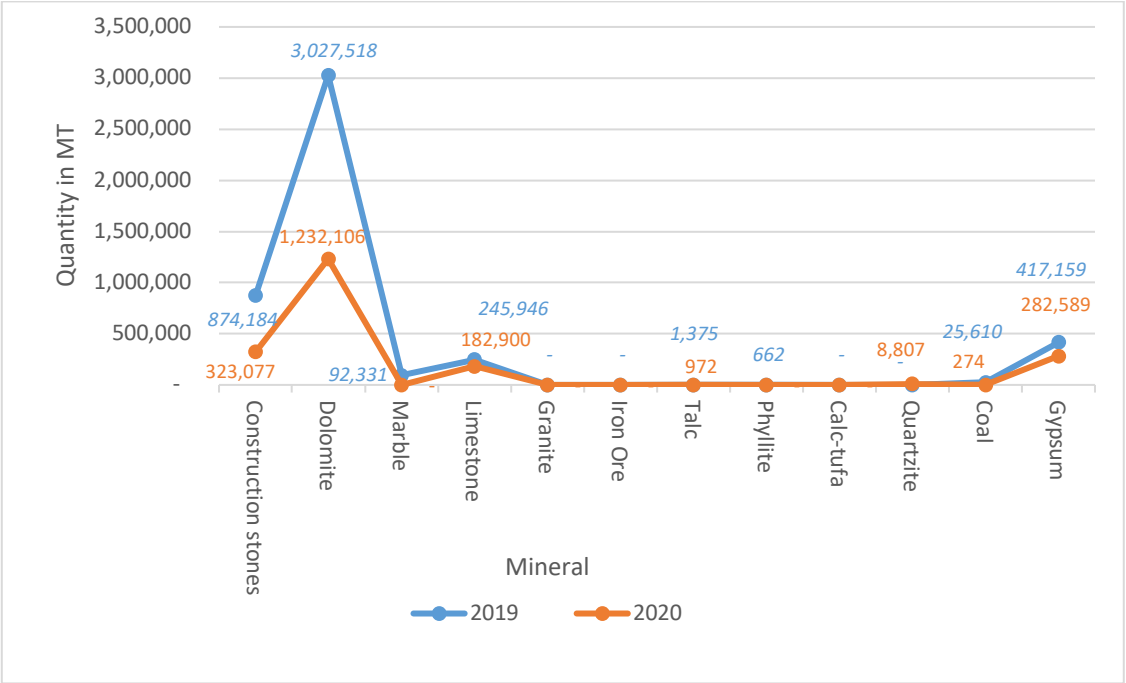
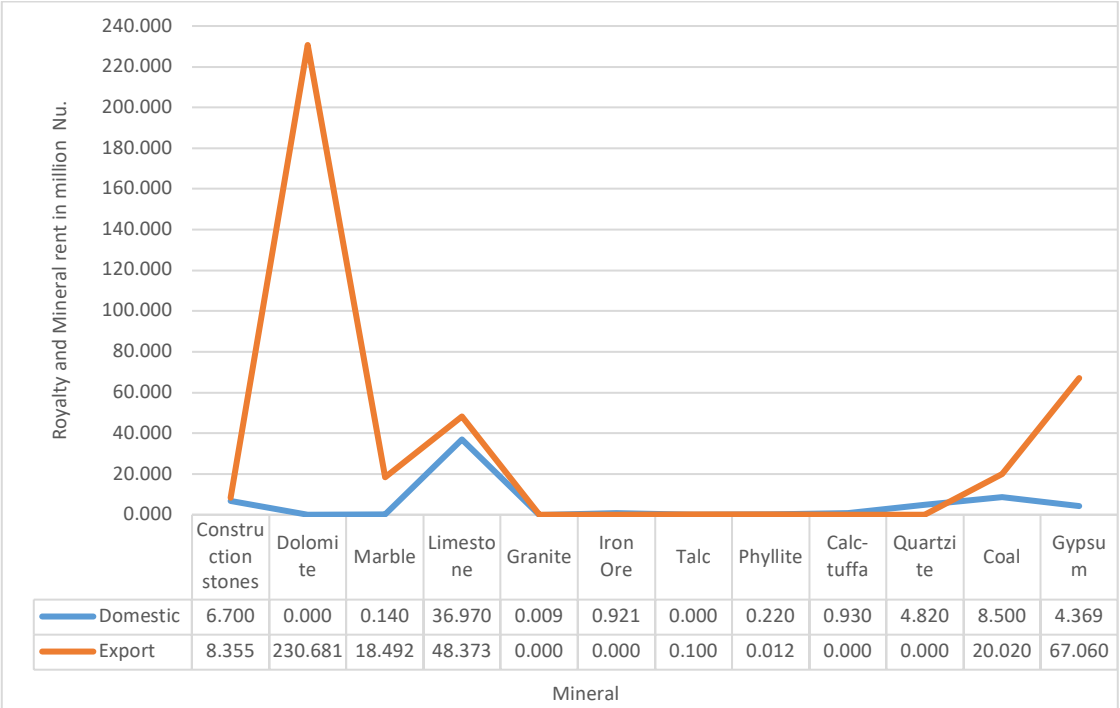


Figure 4: Export of minerals in 2019 & 2020



	Construction stones	Dolomite	Marble	Limestone	Granite	Iron Ore	Talc	Phyllite	Calc-tuffa	Quartzite	Coal	Gypsum
Domestic	6.700	0.000	0.140	36.970	0.009	0.921	0.000	0.220	0.930	4.820	8.500	4.369
Export	8.355	230.681	18.492	48.373	0.000	0.000	0.100	0.012	0.000	0.000	20.020	67.060

Figure 5: Royalty and mineral rent collected by sales of minerals in 2019

Royalty rates for Minerals

Until 2016, only unit-based Royalty system was in practice. With the enactment of Revised Taxes and Levies Act of Bhutan 2016, the country has adopted an Ad Valorem Royalty system for export of minerals. However, the domestic Royalty is levied on unit-based system. Royalty of minerals for domestic market is incentivized to promote and sustain in-country mineral-based industry and infrastructure development. The existing rates of Royalty and mineral rent for domestic and export of minerals are shown in Table 3 and Table 4, respectively. The Royalty contribution to national exchequer from financial year 2014-15 to 2018-19 is shown in Figure 7. The increasing trend in the Royalty contribution over the period is mainly due to the introduction of Ad Valorem Royalty system. The Ad Valorem Royalty rates are levied on Minimum Floor Price (MFP) established at the country exit point or invoiced value, whichever is higher.

Broader Economic Impact

Mining sector generates business opportunities such as hiring of machineries and trucks, supply of good and services, and opportunity for downstream industries. The GDP contribution from mining sector for last five years is shown in Figure 8. The GDP from mining sector is reported from the no. of mines and stone quarries in the country excluding GDP contribution from sectors such as mineral based industries.

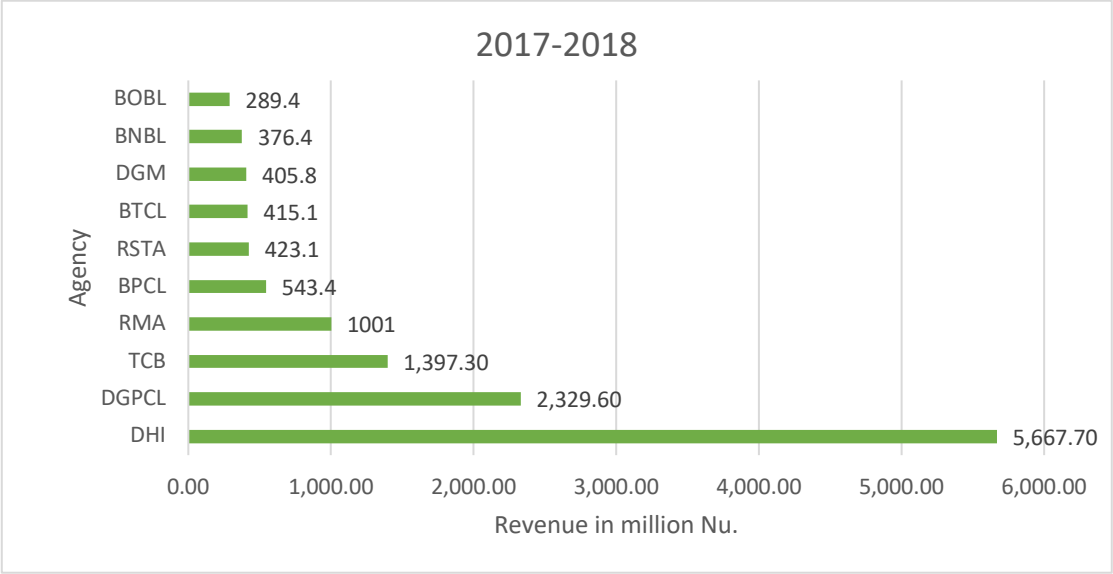


Figure 6. Major revenue contributors in 2017-18

Table 2: Existing royalty and mineral rent rates for domestic sale.

Domestic Royalty and Mineral Rent						
Sl. No.	**Type of Mineral**	**Grade**	**Unit of Measure**	**Royalty (Nu.)**	**Mineral Rent (Nu.)**	**Total**
1	Dolomite	All grade	MT	40	10	50
2	Limestone	All grade	MT	34	8.5	42.5
3	Marble	All grade	MT	34	8.5	42.5
4	Granite	All grade	MT	2.2	0.55	2.75
5	Construction stones	All grade	MT	2.2	0.55	2.75
6	Gypsum	All grade	MT	50	5	55
7	Talc	All grade	MT	40	10	50
8	Phyllite	All grade	MT	4	0.55	4.55
9	Quartzite	All grade	MT	30	5	35
10	Coal	All grade	MT	50	5	55
11	Iron Ore	All grade	MT	20	5	25
12	Shale	All grade	MT	34	8.5	42.5
13	Clay	All grade	MT	2.2	0.55	2.75

Table 4. Existing Royalty and mineral rent rates for mineral export.

Ad Valorem Royalty and Mineral Rent for Export of minerals						
Type of Mineral	**Grade**	**Unit of Measure**	**Minimum Floor Price (MFP) in Nu.**	**Royalty (%)**	**Mineral Rent (%)**	**Remarks**
Dolomite	Powder (white)	MT	1200	6.5	*Amount equivalent to 10% of projected export royalty*	
	Powder (Low grade black)	MT	550			
	Dolo-dust (low grade)	MT	450			
Limestone/ Marble	Lumps	MT	2330	8		
	Powder	MT	2700			
Construction stone	Boulder (Larger than 40mm)	MT	410	2		
	40mm	MT	540			
	30mm	MT	600			
	20mm	MT	625			
	10mm	MT	450			
	Dust	MT	300			
Gypsum	All grade	MT	1850	8		Export to India/Nepal
	All grade	MT	2735			Export to Bangladesh
Talc	All grade	MT	3300	6.5		
Phyllite	All grade	MT	610	3.5		
Ferro-Silicon Grade Quartzite (Undersize)	30mm	MT	600	7		
	20mm	MT	625			
	10mm	MT	450			
	Dust	MT	300			
	Non-sorted	MT	500			
Coal	All grade	MT	8000	7		

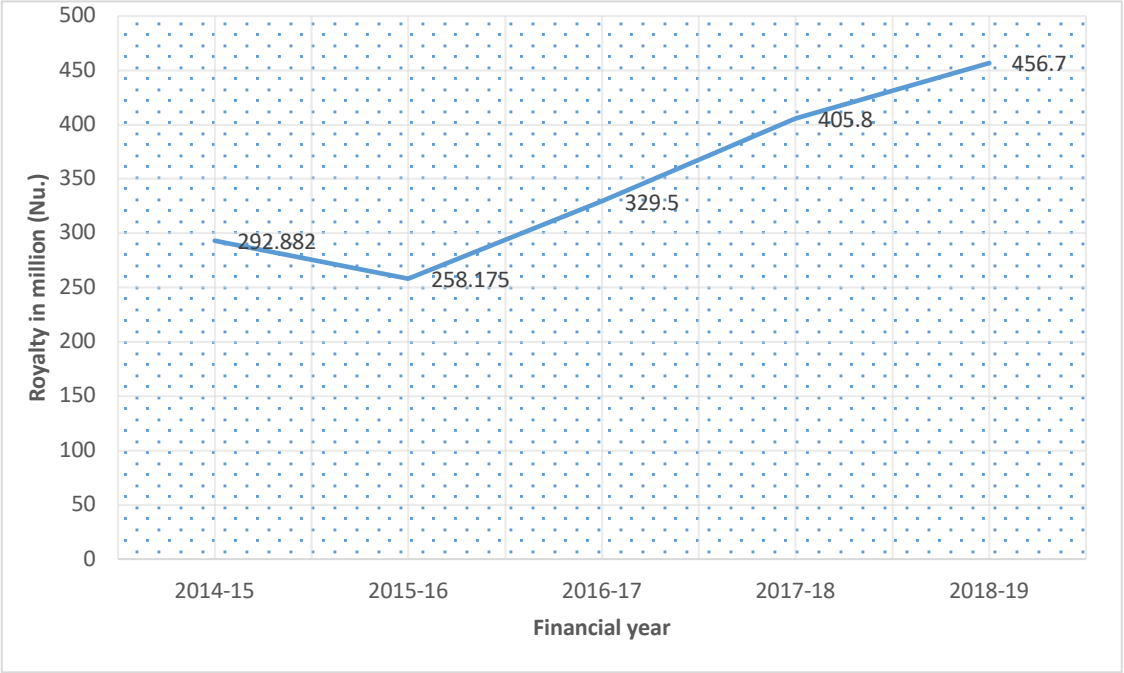


Figure 7. Royalty contribution to National exchequer from 2014-15 to 2018-19

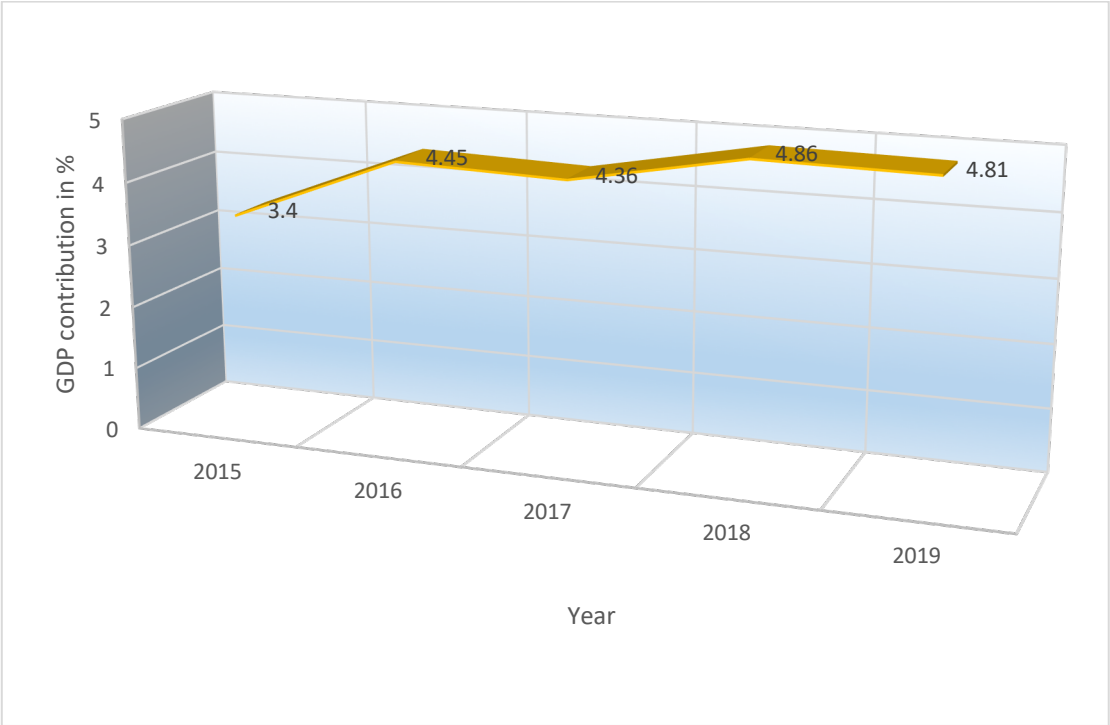


Figure 8. GDP contribution from Mining sector from 2015 to 2019

Mineral Based Industry

The mineral based industries are directly dependent on mining sector for supply of raw materials. The governemnt prioritize allocation of mines as captive to mineral based industry to maximize the benefit to the nations. Some of mines which are leased as captive mines in Bhutan are gypsum for Plaster of Paris (POP) factory, limestone for cement industry, quartzite (high grade) for Ferro- silicon factory, granite for granite factory (for producing slab), and marble for powdering unit (for manufacturing wall putty).

The mineral and mineral based products have become the most important an export commodity. The export data of 2019 shows that seven (italicized text) out of top ten commodities are mineral and mineral based products (Table 5).

Table 5. Top ten commodities export in 2019

Sl. No.	BTC Code	Commodity	Value in million Nu.
1	7202.21.00	*Containing by weight more than 55% of silicon*	7,449,310,836
2	2516.90.10	*Boulders*	1,876,019,657
3	7207.19.00	Other	1,820,479,762
4	2523.29.30	*Portland pozzolana cement*	1,214,225,790
5	0908.31.00	Neither crushed nor ground	1,011,561,609
6	2517.10.00	*Pebbles, gravel, broken or crushed stone, of a kind commonly used for concrete*	897,164,765
7	2520.10.00	*Gypsum; anhydrite*	619,948,469
8	2523.29.10	*Ordinary Portland cement*	564,410,165
9	0701.90.00	Other	534,318,843
10	2518.10.20	*Dolomite, not calcined or sintered, chips*	526,777,819

Employment from the Mining Sector

In addition to economic development, mining sector also provides job opportunity to the job seekers, addressing unemployment issues in the nation. Total jobs opportunities created from the mining sector for the year 2019 is 1388 of which 1189 are men and 199 are women as shown in Figure 8. These numbers are ones that are directly employed in mining only. There are other employments involved in transportation of minerals from source to market. Further, minerals-based industries also provide job opportunity.

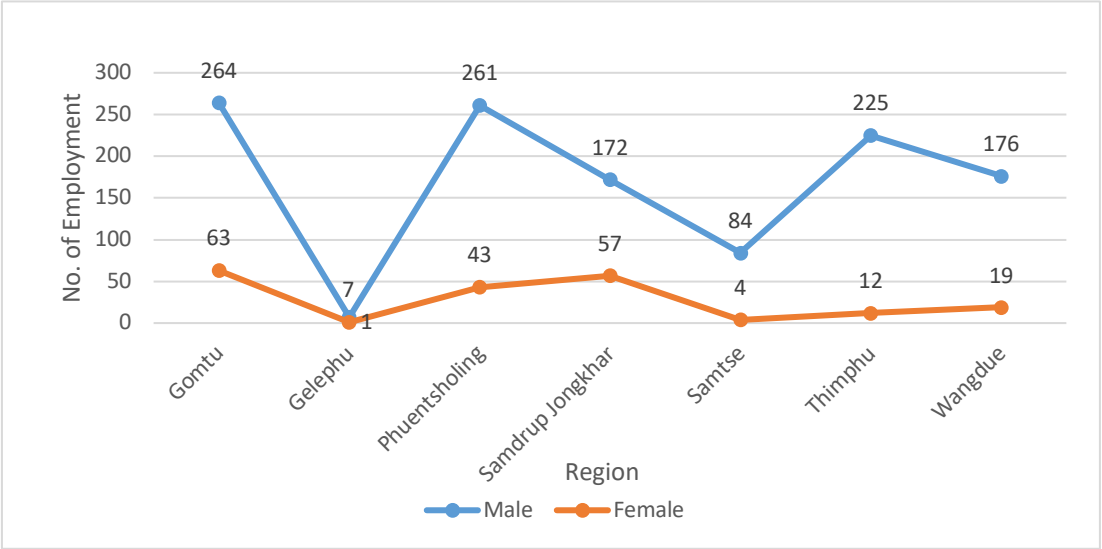


Figure 9. Employment from mining sector

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RESTORATIONS OF MINES AND QUARRIES IN BHUTAN

Pem Dorji Tamang[1]

Introduction

Bhutan is endowed with rich natural resources and minerals. Our long-term commitment and efforts on conservation and preservation of natural ecosystem has been recognized by the global community. As enshrined in the Constitution of the Kingdom of Bhutan, "Every Bhutanese is a trustee of the Kingdom's natural resources and environment for the benefit of the present and future generations and it is the fundamental duty of every citizen to contribute to the protection of the natural environment, conservation of the rich biodiversity of Bhutan and prevention of all forms of ecological degradation including noise, visual and physical pollution through the adoption and support of environment friendly practices and policies". Furthermore, The Constitution mandates that a minimum of sixty percent of Bhutan's total land to be maintained under forest cover for all time to reduce ecosystem degradation.

Currently, 83.90 percent of the country is under forest cover and over 51 percent of the area has been protected by declaring it as a protected area such as parks, wild life sanctuaries, strict nature reserve and biological corridors (Wangmo, 2020). Such commendable commitments have propelled the country to possess rich and diverse natural ecosystems that are home to some of the world's most endangered flora and fauna.

With an overarching philosophy of Gross National Happiness, the developmental activities in the country pursues middle path strategies harmonizing balance between environmental conservation and economic growth. In pursuant to such developmental philosophies, the mining sector of Bhutan also underwent major paradigm shifts seeking to become as environment friendly and sustainable as possible.

Therefore, this article aims to present the overview on legislative requirement for restoration of mines, statistic and projection of restoration activities in Bhutan

[1] Pem Dorji Tamang, Assistant Environment Officer, Department of Geology and Mines, Thimphu, BSc. Environment Management, Royal Thimphu College. Email: pdtamang@moea.gov.bt

Mining in Bhutan- An Overview

The mining and quarrying activities in Bhutan has been steadily rising with four new mines leased in 2020. Currently there are 81 lease active mines and quarries in the country. Despite its small scale, the mining activities in the country can potentially result into substantial environmental degradation such land use changes, removal of vegetations and release of fugitive emissions.

To avoid, minimize and finally offset the environmental impact, various suitable structural and non-structural measures are widely implemented in mines and quarries of the country.

Policy and legal frameworks

The restoration of mines is governed by the multitude of policy and legal frameworks:

1. Mineral Development Policy (MDP) 2017;
2. Mines and Minerals Management Act 1995;
3. Mines and Minerals Management Regulations 2002;
4. Mines Restoration Guidelines (MRG) 2021;
5. National Environment Protection Acts 2007;

The aforementioned legal frameworks obligate the lessee to carry out and complete restoration works within the mining lease period in accordance with the approved Mine Restoration Plan (MRP). The approval shall be accorded upon verification and acceptance of the Department of Geology and Mines (DGM). Further, the MRG, sets detailed standards and procedures for restoration of the mines in the country.

Such obligation ensures that polluter pays the cost of environmental damages and restoration works as prescribed in section 12 of the National Environment Protection Acts, 2007.

Restoration Types and its Planning

Mine Restoration activities carried out in the country can be dichotomies into progressive and final restoration. Progressive restoration is carried out in a phased manner during the operation stage of the mine in areas which do not have any prospect for future use or after exhaustion of minerals in that area. It is a pre-requisite that progressive restoration needs to be approved and updated in the mine plans.

According to Integrated Mine Closure Good Practice Guide, (2019) of ICCM, progressive restoration is associated with host of benefit such as,

1. Improving social acceptances by stakeholders including regulatory body;
2. Forms a knowledge repository to test and improve on subsequent progressive and final restoration;

3. Reduction of financial liabilities at the end of the Life of Mine (LoM);
4. Tax benefits - progressive closure activities are carried out when the asset is generating revenue, and may facilitate tax reduction, but activities carried out after closure typically do not offer the same type of benefits.

The final restoration of mines and quarries are carried out at the end of LoM. The MRP is prepared by the lessee in the prescribed format-framed in MRG.

During the preparation of the MRP, the lessee is required to consult with various stakeholders including communities to determine the post-mine land usage. The post mining land use may include mosaic of other activities such as development of grazing land, parks, playgrounds, infrastructures, etc. The MRP is evaluated and approved by DGM before its implementation.

Environment Restoration Bond

Environment Restoration Bond, as a cash deposit, is collected from miner as a security deposit to ensure adequate funds are available to fund the restoration activities at the end of mining activity.

The current mode of ERB collection is calculated based on the surface area coverage and overburden waste prior to the commencement of mine development work and Nu.4 per MT of actual mineral dispatch in advance as following:

ERB=Ax+By+Cz

Where,

A = Surface area (Hectare)

B = Overburden/inter-burden waste (m^3)

C = Mineral production (MT)

The value of x shall be:

= Nu. 50,000 per hectare for all talc mines

= Nu. 20,000 per hectare if surface area is < 10 hectares

= Nu. 15,000 per hectare if surface area is >10 but < 20 hectares

= Nu 10,000 per hectare if surface area is > 20 hectares

The value of y and z shall be Nu. 5 and 4 respectively.

The ERB amount is refundable to lessee upon verification and acceptance of the final restoration by DGM.

Failure of lessee to complete restoration requirements can led to forfeiture of ERB, either wholly or partially and disqualification of the lessee to apply for new mines or quarries in the country for a period of three years. The forfeited ERB shall be used for carrying out restoration works.

Monitoring

The Regional Office of DGM is mandated to carry out regular monitoring of restoration works to ensure as per the approved MRP.

The biannual reporting by the promoter on the progress coupled with verification reporting on it by Regional Office, DGM enables periodic review to ensure proper restoration.

Restoration profile

27 mines and quarries were formally closed after completion of restoration between 2004 and June 2021 accounting to 59% of the non-operational mines leased until the allotted time. These covers an area of 870

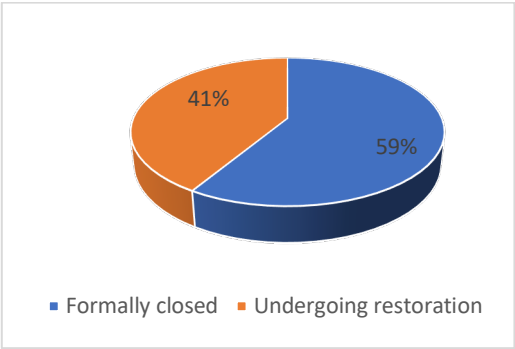

Figure 1. Restoration statistics

Today, there are 19 mines and quarries at various stages of restoration. Further, there about 30 mines and quarries which would undergo restoration by 2030 with lease area of 726 acres. Figure 2 depicts the trend of mines and quarries that may undergo restoration over the period of 10 years. By the end of 2030, it is likely that 1596 acres of mine-out area can be restored in the country.

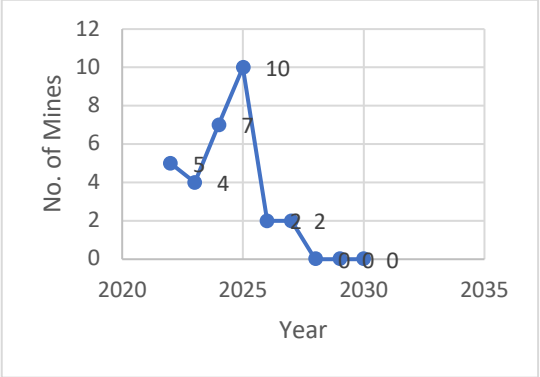

Figure 2. Trend of mine/quarries nearing end of LoM.

Conclusion

Preservation and conservation of environment is one of the important factors to be considered during the planning and implementation of developmental activities, which has been strongly reinforced through legislative and policy frameworks. In recent times, DGM has been focusing on ensuring proper restoration of mines enacting MRG that is expected to help in proper planning, implementation, monitoring and formal closure of mines.

While there are potential for restoration activities in the country, the actual benefits emanating from such ventures are not quantified as of today. Therefore, it is imperative DGM quantify benefits generated by restoration of mines and quarries in the country.

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