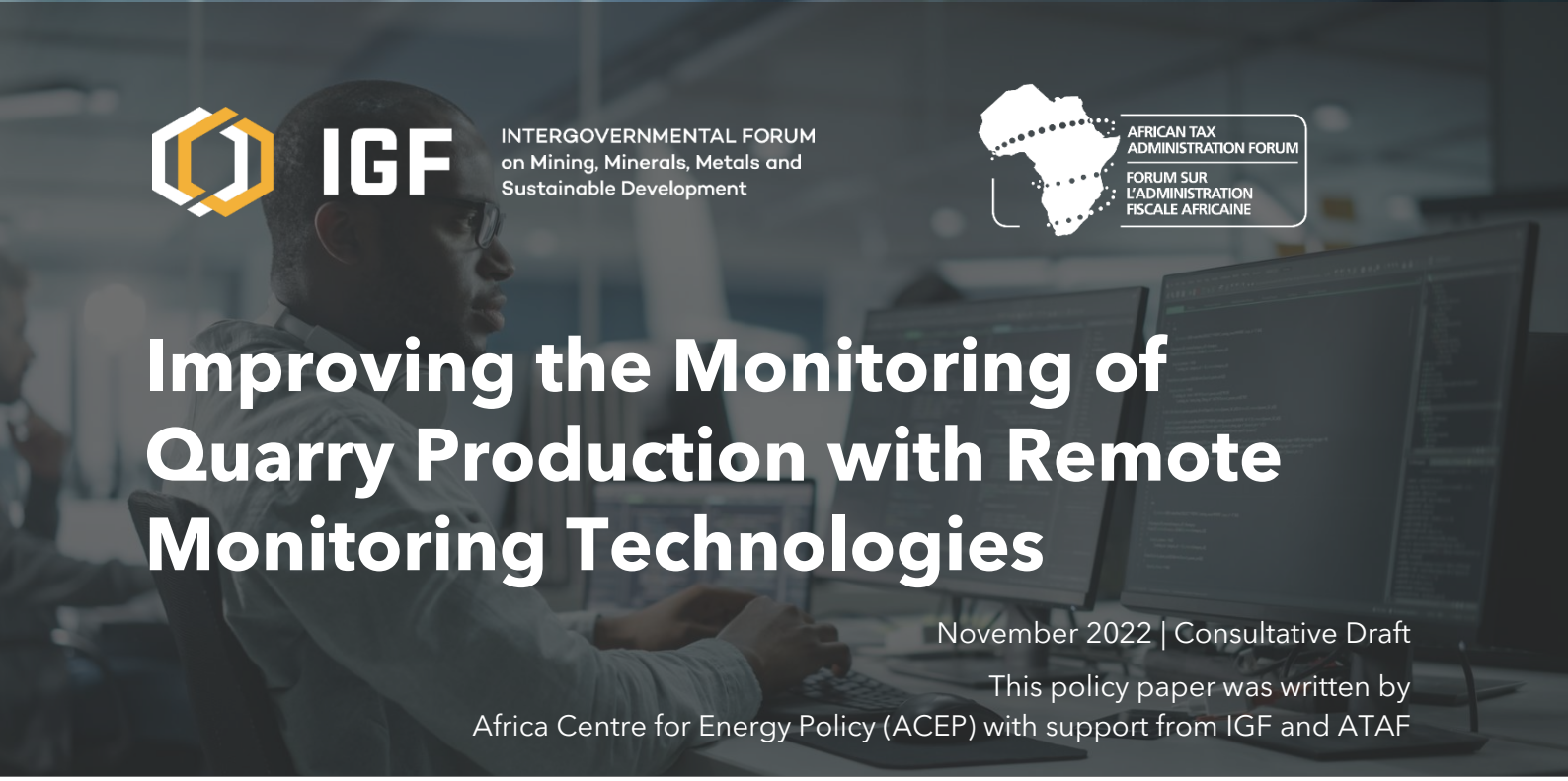

INTERGOVERNMENTAL FORUM on Mining, Minerals, Metals and Sustainable Development

AFRICAN TAX ADMINISTRATION FORUM
FORUM SUR L'ADMINISTRATION FISCALE AFRICAINE

Improving the Monitoring of Quarry Production with Remote Monitoring Technologies

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1.0 Introduction

In most resource-rich countries, regulatory oversight and revenue mobilization efforts in the mining sector focus on precious minerals at the expense of industrial minerals such as quarry aggregates. This limited monitoring stimulates companies' non-compliance behaviour, such as underreporting production outputs and sales, thereby short-changing governments' tax revenue receipts from the sector. This policy paper proposes using remote monitoring technology to afford tax authorities in Ghana and other developing and middle-income countries the ability to monitor the production volumes and sales of quarry aggregates by quarrying companies off-site. The technology holds the potential to curb incidences of underreporting and empower governments to generate maximum revenue potential from the quarrying sector through optimal taxation. However, seamless implementation of the technology may require some legislative changes that enforce the use of the technology in the reporting regulations for mining companies. This policy paper further proposes some financing options for investment that are differentiated between existing and new companies and impose minimal shocks on governments' annual budgets and companies' finances.

Quarry aggregates, such as sand, gravel, and crushed stones, are industrial minerals that constitute an essential component of the modern, concrete-based built environment. They form part of the basic materials for constructing roads, housing, and rail infrastructure. The rising demand for housing and investment in infrastructure further contributes to the demand and consumption of quarry aggregates in Africa (Boakye et al., 2021). In addition, quarry aggregates are more locally traded and less exposed to global commodity market dynamics. Thus, the quarry industry is essential to smoothen revenue shortfalls from precious minerals.

Prior analysis of the quarry industry by the Africa Centre for Energy Policy (ACEP) indicates that the revenue mobilization potential of the quarry sector is hampered by inadequate regulation and monitoring (Boakye et al., 2021). Ghana's monitoring in the mining sector primarily focuses on precious minerals such as gold, neglecting other essential industrial minerals. Furthermore, ACEP's observations from field visits to quarry sites in Ghana did not show any evidence of operational visibility of the Ghana Revenue Authority (GRA), the authorized tax revenue mobilization institution. The analysis also shows the significance of the revenue potential of the quarry sector, which was estimated to be about 18 times more than actual receipts by the government. ACEP's interaction with officials from the GRA revealed that inadequate records on quarries compound the difficulties in determining tax and royalty commitments by quarrying companies (see Box 1 for a summary of ACEP's initial study of the revenue potential of the quarry sector).

The revenue potential of the quarry industry calls for a robust and cost-effective mechanism that monitors the operations of quarries in Ghana. ACEP's study recommended using technology to enhance regulatory agencies' monitoring potential. These technologies include real-time video surveillance tools that capture export volumes from the production sites and enterprise resource systems that coordinate information sharing among local authorities and government regulatory agencies.

The Government of Ghana has realized the importance of the quarry sector and the need for leveraging digitization for revenue mobilization. In April 2022, the Ministry of Finance indicated its readiness to partner with the private sector to introduce digital systems to monitor quarrying and other industrial mining activities to enhance revenue mobilization (Ministry of Finance, 2022). This commitment was part of the measures taken to restore the economy, given the global economic challenges. The Government of Ghana's decision to consider using technology for revenue mobilization in the quarry industry suggests that ACEP's ideas for deploying such technologies could be adopted in other countries.

This study provides a detailed description of the technologies that can be used for monitoring quarry production volumes in real time. It involves the technical components, functions of the technology, and investments required for its implementation. ACEP believes that this study could provide a valuable blueprint for the Government of Ghana and broadly for other economies that aspire to leverage technology to maximize their extractive sector revenue mobilization potential. In addition, many countries' current pursuit of digitization provides a favourable environment for deploying digital technologies. Therefore, this idea lends itself to ongoing digitization schemes and complements ongoing efforts made by governments.

Box 1. A summary of ACEP's initial study on the revenue potential of the quarry industry

A sample of quarries across the main aggregate-producing regions of Ghana was selected from a database of quarries operating in Ghana. To independently verify the production volumes of quarry aggregates from quarrying companies, truckloads of quarry aggregates directly sourced from the sampled quarries were used as proxies for production.

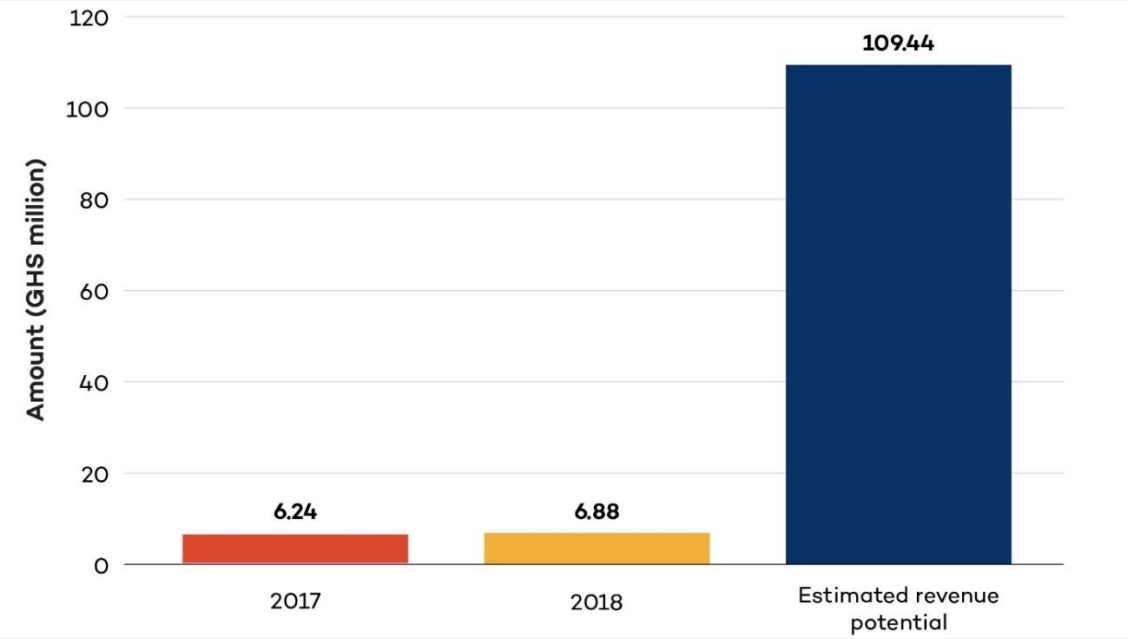
Estimation assumptions

1. **Truckloads of quarry aggregates directly sourced from the mines were used as a proxy for production.** This approach was adopted to verify the production volume of quarry aggregates independently.
2. **A one-month shutdown and maintenance period was assumed to estimate the annual production volumes for each quarry site.** This shutdown period accounted for machine maintenance and public holidays.
3. **Annual production for the sampled sites was determined using a 95% confidence interval estimate** for accounting for potential variations in annual production and determining scenarios for production.
    a. **Lower production scenario:** Accounts for the least attainable production volume value (lower confidence interval limit).
    b. **Base production scenario:** Accounts for the second highest value of attainable production (point estimate of the annual production volumes).
    c. **Upper production scenario**: Accounts for the maximum value of attainable production volumes (upper confidence interval limit).

Table 1. An estimate of the Government of Ghana's revenues from sample data

	Amounts (GHS million)		
	Lower production scenario	**Base production scenario**	**Upper production scenario**
Company costs and revenues			
Total revenue	401.94	558.86	715.78
Royalty payments	20.10	27.94	35.79
Operation and maintenance costs	133.98	186.29	238.59
Capital allowance	80.39	111.77	143.16
Total payments	*234.47*	*326.00*	*417.54*
Net profit	*167.48*	*232.86*	*298.24*
Government take			
Royalyies	20.10	27.94	35.79
Corporate income tax	58.62	81.50	104.38
Total government revenue	**78.71**	**109.44**	**140.17**

Figure 1. Revenue potential and actual government revenues from the quarry sector in (2017 and 2018)



Source: Boakye et al., 2021.

2.0 Background of the Technology

The idea consists of using a remote monitoring system to track the liftings of quarry aggregates and estimate sales by companies for appropriate taxation. It aims to empower and capacitate tax authorities to independently track the liftings (sales) of quarry aggregates to curtail incidences of underreporting and tax evasion. The proposed system would comprise a laser scanning technology and software to accurately measure volumes of quarry materials carried by truckloads. It also has a cloud-based data storage, analysis, and sharing platform that affords real-time information sharing among state agencies.

2.1 The Operational Mechanism of the Technology

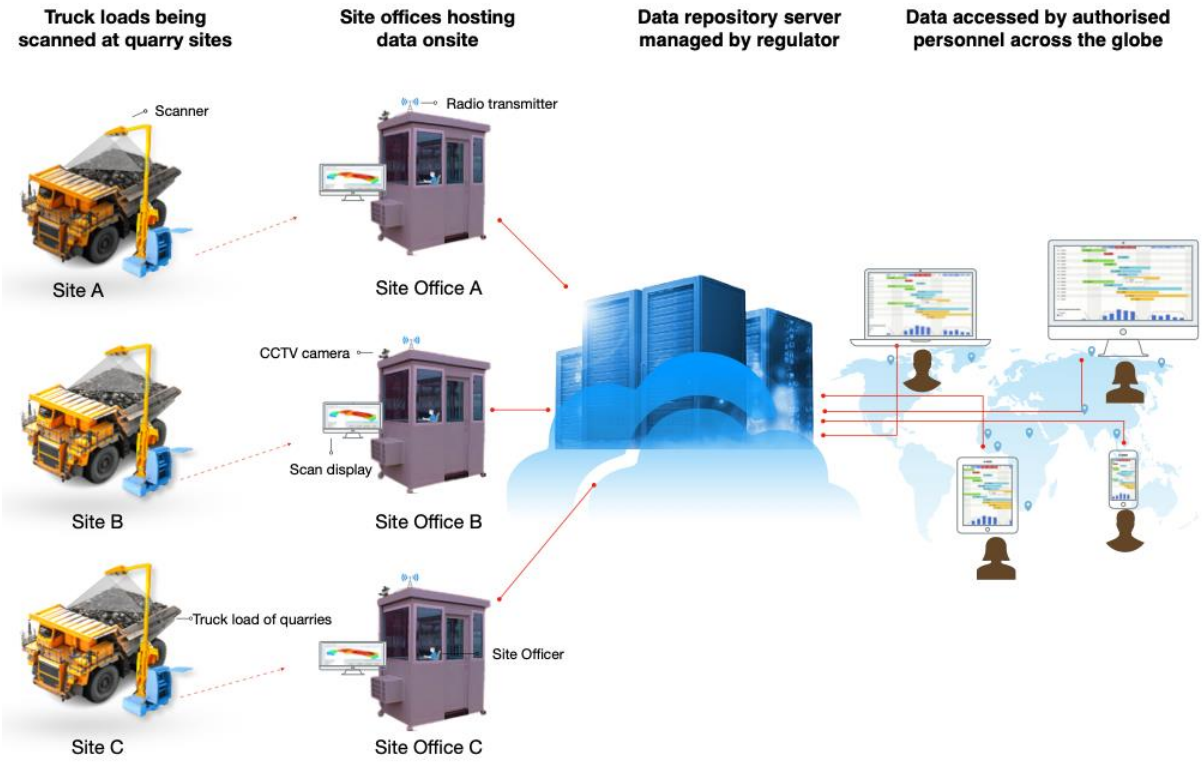
Quarry aggregates are usually transported from the quarrying sites to customers using tipper trucks of varying sizes, usually measured in cubic metres. The remote monitoring system, mounted at vantage points, makes it possible to scan the trucks as they drive beneath the scanner upon entry and exit. At the entry point, the scanner component of the system scans the truck to determine the initial volumes of quarry aggregates already contained in the entering trucks. The initial scan is important to ensure that the final volume measured reflects quarry aggregates lifted from the quarrying site and not aggregates imported from elsewhere.

Quarry aggregates are then loaded into the trucks using load haulage systems. The loaded trucks are scanned again to determine the net volume (i.e., the difference between the initial load upon

entry and the final load). The second scanning determines the effective volumes of quarry aggregates lifted from the quarry site based on earlier measured initial volume. The system automatically generates a receipt containing data on the type and volume of quarry aggregates lifted and the time of lifting. The truckloads' unit price and total price are generated, given that pricing information on the various quarry aggregates is already fed into the system.

Each respective quarry site generates similar information on volume loads and respective prices. At each quarry site, the information is managed by attendants or managers of the site. The relevant information is transmitted to a central data repository managed by the regulator or tax authority. Authorized personnel can query the data to obtain information on companies, products, or sales volumes for tax purposes. Figure 2 is a flowchart that graphically describes the monitoring system.

Figure 2. A graphical representation of the remote monitoring system



Source: ACEP; reprinted with permission.

The remote monitoring system provides regulators and tax agencies with accurate and real-time information on sales volumes for tax purposes. Other mature technologies used in the mining sector to monitor production outputs of mining companies include Unmanned Aerial Vehicles (UAVs, e.g., drones) and weighbridges. Drones are flown over mining sites to examine areas prone to physical hazards (Behrman et al., 2019). They provide high-definition photographic evidence that effectively measures changes in quarry landscapes and estimates the size of the site and production stockpiles. However, they are less practicable in providing real-time monitoring of quarry liftings and sales.

Weighbridges could be a convenient alternative to the proposed technology if the information on quarry liftings could be accessed in real time by authorized tax and regulatory agencies. However, the system must be well calibrated to accurately convert the net weight of various quarry aggregates into their correct volumes. Measurement accuracy is essential since quarry aggregates are sold commercially in volumetric units (mainly cubic metres). The proposed monitoring system scans the content in the bin or dump box of the truck for volumetric assessment. Therefore, it provides a more accurate estimate of quarry aggregate volumes than weighbridges.

2.2 Expected Impact of the Technology

The proposed remote monitoring system is helpful for governments in obtaining relevant and accurate company and product-specific information for revenue mobilization and other monitoring purposes. Thus, the technology provides a more robust monitoring mechanism and prevents underreporting of production volumes, which impacts government revenues from quarrying sites. In addition, such a robust mechanism can increase government revenues from the quarrying sector to support the national budget.

However, the benefits of the technology are not limited to government agencies alone. Quarrying companies also benefit from accuracy in volume estimations and improved efficiencies in operations. For example, the proposed technology eliminates manually counting truckloads, reducing inaccuracies related to manual counting. Further, remote monitoring technology ensures that accurate volumes of quarry aggregates are sold at the quarrying sites. Thus, customers receive the right amount of aggregates purchased, and companies receive payments for the amount of load they sell.

The technology can improve tax compliance among quarry companies, ensuring fair competition by eliminating pricing advantages for non-compliant companies. Finally, deploying the solution would provide a reliable, centralized point for ease of access to quarry production data and curb bureaucracy in data access, thus attracting investment in the sector.

3.0 Monitoring and Legislative and Financial Assessments

The successful implementation of the system is premised on compliance on the part of quarry companies. Therefore, it is vital to highlight monitoring approaches and potential changes in regulations and legislation to deepen compliance among companies and government agencies. The success of implementation also hinges on funding available for investment. This section details some enhanced monitoring mechanisms and legislative changes needed to augment the system and enforce compliance. The section also provides some information on the cost components of the system and possible financing options governments can explore.

3.1 Monitoring Mechanisms

Despite the potential benefits described in the previous section, the main risk is non-utilization. There is a possibility of non-compliant companies evading the system by allowing trucks to use

undesignated routes, which avoids the scanning system and provides an inaccurate assessment of production and sales volumes. Faulty scanners and occasional server downtimes can also hamper the measurement and upload of accurate information on quarry aggregates at various quarry sites.

Video surveillance tools such as cameras can accompany remote monitoring systems. These cameras will allow tax agencies to monitor quarry sites to detect any incidence of non-compliance by companies. The cameras can be mounted at vantage points to determine truckloads of quarry aggregates that enter and exit the quarry sites. The government must also embark on periodic visits to prevent illegal and unauthorized tampering with the remote monitoring technologies. In addition, the government must have a maintenance plan to ensure that the various monitoring technologies are in good condition and the right personnel carry out the required troubleshooting and repairs when the monitoring systems develop faults.

Further, tax authorities must collaborate with subnational governments (or district assemblies) to provide information about specific quarry site operations. Usually, officers of the district assemblies are stationed at the entrance of the sites for the collection of tolls from truck drivers. Thus, these officials have adequate information about the quarry sites and can assist in monitoring through effective collaboration with the tax authority.

Technology has advanced in many business operations within the various sectors of the economy. Consequently, governments must consider leveraging technology to effectively improve their revenue mobilization potential and offering periodic capacity training sessions to hone their staff's technological skills.

3.2 Legislative Requirements

The proposed idea does not introduce changes in the fiscal regime of the mining sector. Instead, it seeks to improve revenue generation from existing sources through effective revenue reporting. Therefore, implementing the idea may not require any changes to the fiscal regime within the sector. However, the implementation of the technology may require some changes in the reporting guidelines by companies.

In Ghana, the Minerals and Mining (General) Regulations, 2012 obligate holders of mining leases to keep complete and accurate records of mining operations. These records include production volumes, quantities sold, revenue received, and royalties payable. The law further requires the records to be maintained in an acceptable format and submitted monthly to the sector regulator.

The legal frameworks of the mining sector could specify the form of reporting requirements for industrial minerals as invoices from a government-approved remote monitoring system. However, this may require an amendment in the legal framework that addresses:

- The installation of approved remote monitoring systems at industrial mineral sites.
- Guidelines on the utilization of the monitoring systems.
- Responsibilities of the government and companies regarding the operation and maintenance of the system.

Finally, in the rare event that stabilization clauses in existing leases hinder the enforcement of volume scanning system requirements, enhanced engagement efforts and the renegotiation of contracts may be required.

3.3 Implementation Costs and Financing Options

The main cost components for implementing the technology are the capital and installation costs for the equipment, operation and maintenance costs, and the cost of capacity building and ongoing capacity development. Interactions with remote monitoring system providers reveal that the average unit cost of such technologies ranges from USD 80,000 to USD 100,000 per site, depending on the technical specifications and the nature of customization required. Again, operating and maintenance costs account for between 4% and 10% of the price of the technology. Thus, the main concern for the government would be the entity responsible for the investments and the requisite cost reduction investment models. Companies that provide sales and support services for such remote monitoring systems include LASE, Modular Mining, Walz, and LoadScan.[1]

The government may choose among numerous models deemed suitable within their context for financing options. The funding options for the technology may vary between existing and new quarry companies. For newer quarry concessions, regulation can require that new quarries install the requisite remote monitoring systems at the sites. For example, the Government of Queensland, Australia, requires that holders of mineral resource rights (mineral resource authority holders) release the results of remote sensing surveys to the responsible authorities (Department of Resources, 2021).

Two financing options are available for older quarries. First, the government can consider investing in the technology at the various quarry sites. However, this option requires high initial capital and depends on the government's ability to commit itself to such capital requirements, especially in a situation where it is concerned about meeting social and other infrastructural needs in the country. Thus, an approach that reduces the cost commitment of governments is opportune.

Alternatively, the government can encourage the quarry companies to invest in monitoring systems at their sites while it provides tax incentives within their capital recovery period. Furthermore, the government can encourage accelerated depreciation, where companies are allowed to write off their capital costs within a shorter space of time than the norm for the technologies over their useful economic lives. At face value, this treatment would not change the total amount of depreciation to be charged; however, it would increase the present value of the depreciable amount by bringing them forward and making them closer to the time the technologies are adopted. Additionally, the government can support companies with difficulties securing technology investments.

[1] For more information on each of these monitoring systems, please see: LASE, https://lase-tvm.de/en/?utm_source=google&utm_medium=cpc&utm_campaign=12912425208&utm_content=121102742349&utm_term=load%20scanner&gclid=CjwKCAjwwo-WBhAMEiwAV4dybSPolxaySTnnbc1JcLq0vaJG1QqjsnSkBC7nmYfV8AJ6ESICCfOR0hoCJboQAvD_BwE; Modular Mining, https://www.modularmining.com/our-solutions/load-and-haul/; Walz, https://www.walzscale.com/truck-scales-in-mining/; LoadScan, www.loadscan.com

4.0 Conclusion

Industrial minerals, such as quarry aggregates, can provide a substantial revenue stream for many developing countries. However, limited monitoring in the sector does not allow governments to take advantage of such revenue generation potential. Within the current context of digitization, technological advancements can provide practical and effective approaches for regulators and tax agencies to monitor operations within the sector. Leveraging technology enables agencies to independently verify reported quarry production volumes and sales to apply governments' appropriate taxes and royalty commitments.

ACEP proposes a remote monitoring system to enhance regulation in the quarrying sub-sector. The study is a practical description of a monitoring technology that was recommended after assessing the revenue generation potential of Ghana's quarry industry. The idea demonstrates that volume scanning systems mounted at the entrances and exits of quarry mines can accurately compute the volume of liftings of quarry materials. This information is then wirelessly transmitted to and hosted on a cloud-based data platform that can be accessed by tax administrators, mining sector regulators, and other subnational or local assemblies.

While the system potentially offers a cost-beneficial functionality for monitoring quarrying activities, some changes in regulations may be needed for the seamless implementation of the technology. These regulatory changes would give tax authorities the mandate to enforce the system's installation on each quarry site and provide quarrying companies with reporting guidelines to provide data on sales volumes generated from the system for taxation purposes. Finally, this idea demonstrates the feasibility of financing technologies to enhance monitoring efforts in the quarrying sector through partnering with quarry companies to meet the investment cost of the technology and then granting tax incentives to companies to recover the investment cost borne on the technology.

The proposed technology, therefore, proves to be commercially mature and easy to implement. It holds the potential to increase domestic revenue mobilization from the quarrying sectors to support the budgets of implementing countries.

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