

Techno-Economic Evaluation of a Proposed Medium-Scale Granite Aggregate Quarry in Abuja, Nigeria.

O.B Ogunyemi¹, I. Isa²

¹Department of Mineral and Petroleum Resources Engineering, Kaduna Polytechnic, Kaduna

²Department of Mining Engineering, Federal University of Technology Akure, Nigeria

DOI: <https://doi.org/10.51244/IJRSI.2026.1308000291>

Received: 07 September 2026; Accepted: 12 September 2026; Published: 22 September 2026

ABSTRACT

This study evaluated the techno economic viability of a proposed medium scale granite aggregate quarry in Waru Community, Abuja, Nigeria. The study focused on geological potential, capital and operational costs, market demand, pricing trends, and economic viability. The methods used included geological survey mapping, satellite imagery, field observation, petrological assessment, resource estimation, cost estimation, market survey, price analysis, demand forecasting, and financial modelling using Net Present Value, Internal Rate of Return, payback period, and break even analysis. The geological assessment showed that the proposed site is favourable for granite aggregate production, with expected minerals such as quartz, feldspar, and mica. The cost analysis revealed an estimated capital cost of USD 1,000,000, while annual operational cost was estimated between USD 120,000 and USD 180,000. Market analysis showed strong demand for granite aggregate in Abuja due to housing, road construction, and infrastructure development, with projected prices ranging from ₦4,500 to ₦5,800 per ton. The economic analysis produced a positive NPV of ₦120 million, an IRR of 20 percent, a payback period of 3.5 years, and a break even output of 50,000 tons per year. The study concluded that the proposed quarry is technically feasible, economically viable, and suitable for investment if properly managed. It recommended further geological testing, environmental impact assessment, cost control, and long term supply agreements before full implementation.

Keywords: Granite Aggregate, Techno-Economic Feasibility, Quarry Development, Economic Viability, Abuja Construction Industry.

INTRODUCTION

Granite aggregate was identified as one of the most important industrial minerals used in the construction industry worldwide. It served as a fundamental raw material in the production of concrete, asphalt pavement, road base materials, building foundations, and other civil engineering structures due to its high strength, durability, resistance to weathering, and ability to withstand heavy loads. Granite aggregates were produced through quarrying operations involving the extraction of suitable rock materials and their processing into specific sizes and shapes required for construction purposes. The production process involved several stages, including geological investigation, drilling, blasting, excavation, hauling, crushing, and screening. Each stage required significant technical and financial considerations, making proper planning, cost evaluation, and operational management essential for successful quarry development (Bilim et al., 2017). The increasing demand for infrastructure development, urban expansion, and population growth globally contributed significantly to the rising consumption of construction aggregates.

Unlike high-value minerals, aggregates were bulky and relatively low-cost materials, making transportation costs a major factor affecting their final market value. The economic performance of quarry operations was therefore strongly influenced by their location relative to major construction markets, as shorter transportation distances reduced logistics expenses and improved market competitiveness. Quarry operations located near rapidly developing urban areas had considerable economic advantages because they provided easier access to customers and reduced delivery costs (USGS, 2007). This relationship between quarry

location, production costs, and market accessibility demonstrated the importance of evaluating the economic suitability of quarry locations before investment decisions were made.

Studies carried out on Nigerian granite quarry operations demonstrated that properly managed quarry businesses had the potential to achieve significant economic benefits. Research conducted in Akure South Local Government Area revealed that well-planned quarry operations were capable of recovering initial investment within a short period and generating considerable profits throughout their operational lifespan. The study further indicated that early payback periods were achieved through effective production planning, efficient equipment utilization, and proper management of operational costs (Alaba & Agbalajobi, 2017). These findings highlighted the importance of effective management practices and cost control measures in determining quarry profitability.

The cost structure of quarry operations was recognized as a major factor influencing economic performance. Quarry production involved several cost components, including drilling and blasting, equipment acquisition and maintenance, fuel consumption, labour, spare parts, transportation, and administrative expenses. Among these components, drilling and blasting activities accounted for a significant proportion of production costs because they directly influenced rock fragmentation efficiency and the productivity of subsequent crushing operations. Previous studies on Nigerian quarry operations indicated that proper analysis of production costs helped identify areas where operational improvements and cost reductions could be achieved, thereby improving the overall profitability of quarry projects (Melodi, Onipede & Oluwafemi, 2020).

Environmental and social considerations were also recognized as important aspects of modern quarry development. Quarrying activities contributed positively to economic development through employment generation, local business opportunities, and the supply of essential construction materials. However, uncontrolled quarry operations could result in environmental problems such as land degradation, dust emissions, noise pollution, vegetation destruction, and negative effects on surrounding communities. Recent studies on quarry activities in Nigeria emphasized the need for sustainable quarrying practices, effective environmental management systems, and compliance with regulatory requirements to ensure that economic benefits were achieved without causing unacceptable environmental impacts (Oshim et al., 2024).

The Federal Capital Territory (FCT), Abuja, experienced rapid urban growth and continuous infrastructure development, creating a significant demand for granite aggregates. The expansion of residential areas, commercial developments, road construction projects, and government infrastructure initiatives increased the need for reliable sources of construction materials. However, despite the growing demand, the establishment of new medium-scale quarry operations remained challenging due to high capital requirements, competition from established large-scale operators, uncertainties associated with geological conditions, fluctuating operational costs, and regulatory requirements.

The study was conducted in Waru community, located within the Federal Capital Territory (FCT), Abuja, Nigeria, where the proposed medium-scale granite aggregate quarry site was assessed. The location was considered suitable due to its proximity to developing construction areas and accessibility to transportation networks connecting major markets within Abuja and surrounding regions. The assessment focused on determining whether the granite deposit in the area possessed sufficient geological potential and economic value for quarry development.

The study therefore evaluated the techno-economic viability of the medium-scale granite aggregate quarry in Waru, Abuja. The research assessed the geological characteristics of the granite deposit, estimated the capital and operational costs required for quarry establishment and operation, analysed market demand and pricing conditions for granite aggregates, and evaluated the financial performance of the project using economic indicators such as Net Present Value (NPV) and Internal Rate of Return (IRR). The findings provided useful information for investors, developers, and stakeholders interested in sustainable quarry development and contributed to improved understanding of the technical and economic requirements for establishing medium-scale granite quarry operations in Abuja and similar locations in Nigeria.

Research Gap

Previous studies on granite quarrying in Nigeria have provided valuable information on quarry operations, production costs, profitability, and environmental challenges. However, most of these studies have focused on existing large-scale quarry operations and general assessments of aggregate production, with limited emphasis on the feasibility of establishing new medium-scale quarry projects. In particular, there is a lack of detailed studies that combine geological assessment, cost estimation, market evaluation, and financial analysis for granite quarry development within the Abuja region.

The increasing demand for granite aggregates resulting from rapid urban growth and infrastructure development in Abuja highlights the need for location-specific feasibility studies. However, limited information exists on the technical and economic viability of developing a medium-scale granite aggregate quarry in Waru community, Abuja. This study addresses this gap by providing an integrated techno-economic evaluation of the proposed quarry, considering the geological potential, investment requirements, operational costs, market conditions, and projected economic returns necessary for sustainable quarry development.

METHODOLOGY

The study employed an integrated techno-economic evaluation approach to assess the feasibility of establishing a medium-scale granite aggregate quarry in Waru, Abuja. Data used for the study were obtained from geological maps, field observations, laboratory investigations, cost records, market surveys, industry reports, and financial modelling tools.

The study began with site exploration and assessment, where geological information, satellite imagery, and field observations were used to evaluate the suitability of the quarry location. The Waru area was selected based on the presence of granite outcrops, accessibility, proximity to construction markets, and favourable conditions for quarry development. Petrological analysis was conducted on collected granite samples to determine their mineral composition and suitability for construction aggregate production. The analysis focused on identifying major minerals such as quartz, feldspar, and mica, which influence the strength, durability, and quality of granite aggregates. Resource estimation and mapping were carried out using geological data and spatial measurements to determine the extent and approximate volume of the granite deposit. The estimated reserve was used to evaluate the potential production capacity and lifespan of the proposed quarry. The cost evaluation involved the assessment of both capital expenditure (CAPEX) and operational expenditure (OPEX). Capital costs included land preparation, quarry infrastructure, and equipment acquisition, while operational costs covered labour, fuel, maintenance, blasting activities, and transportation expenses. A market assessment was conducted to determine the demand, pricing trends, and future market potential of granite aggregates in Abuja and surrounding areas. Data were collected from construction companies, quarry operators, suppliers, and relevant industry reports. Factors affecting aggregate prices, including transportation costs, fuel prices, and production expenses, were analysed. Finally, the economic viability of the quarry project was evaluated using financial indicators such as Net Present Value (NPV), Internal Rate of Return (IRR), and break-even analysis. These methods were applied to determine the profitability, investment attractiveness, and production requirements necessary for sustainable quarry operation. This methodology provided a comprehensive assessment of the technical, economic, and market factors required to determine the feasibility of the proposed medium-scale granite aggregate quarry in Waru, Abuja.

RESULT

Result of Geological Assessment of the Proposed Quarry Site

The geological assessment indicates that the proposed quarry area in Waru community, Abuja, has good potential for granite aggregate production. The site is located within a region that is geologically suitable for granite occurrence, and the rock material is expected to contain major granite minerals such as quartz,

feldspar, and mica. These minerals are important because they contribute to the strength, hardness, and durability of granite used in construction works.

Table 1: Projected Geological Characteristics of the Proposed Quarry Site

Parameter	Result
Study location	Waru community, Abuja
Coordinates	8°55'26.0"N, 7°27'28.0"E
Expected rock type	Granite
Major minerals expected	Quartz, feldspar and mica
Expected aggregate use	Concrete, road base, asphalt and construction fill
Accessibility	Moderate to good
Quarrying method	Open pit quarrying with drilling, blasting, crushing and screening
Overall geological rating	Favourable

The result in table 1 shows that the proposed site is suitable for medium scale granite aggregate production. The presence of granite in the area, combined with its closeness to Abuja's construction market, gives the site both technical and commercial advantages. The expected mineral composition suggests that the material would be suitable for construction aggregate if confirmed through petrological and mechanical laboratory tests. However, before full investment, detailed field mapping, core sampling, compressive strength testing, abrasion testing, and reserve estimation should be carried out to confirm the quantity and quality of the deposit.

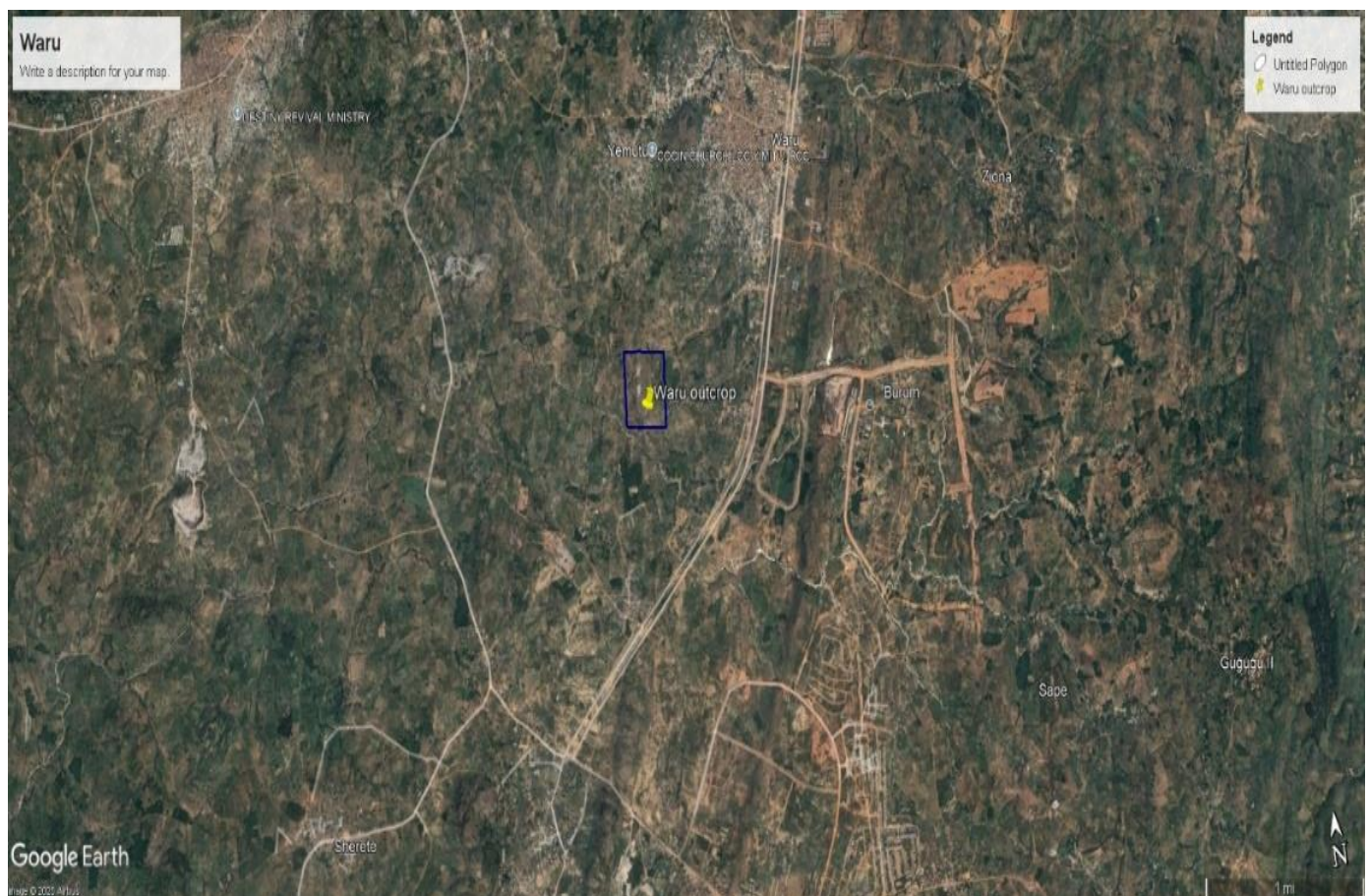


Figure 1 Image of the Outcrop at Waru Abuja (AMAC)

Result of Capital Cost Estimation

The capital cost result shows that establishing the proposed medium scale granite quarry would require a substantial initial investment. The major cost components include land acquisition, crushing plant, excavators, haul trucks, access roads, water supply, drilling equipment, and other supporting infrastructure.

Table 2: Estimated Capital Cost for the Proposed Quarry

Cost item	Estimated Cost in USD
Land acquisition	150,000
Crushing plant	400,000
Excavators and haul trucks	250,000
Infrastructure such as roads and water	125,000
Drilling and blasting equipment	30,000
Other installation and support costs	45,000
Total estimated capital cost	1,000,000

The result in table 2 indicates that machinery and crushing equipment would account for the largest share of the startup cost. This is expected because granite quarrying depends heavily on mechanical extraction, crushing, screening, and haulage. The crushing plant alone represents a major investment because it determines the quarry's processing capacity and final product quality. The high capital requirement also supports the problem identified in the study, where large quarry operators dominate the market because they possess bigger machinery and stronger production capacity.

Result of Operational Cost Estimation

The estimated annual operational cost of the proposed quarry falls between USD 120,000 and USD 180,000. The main operational cost items are labour, fuel, maintenance, explosives, blasting accessories, and transportation.

Table 3: Estimated Annual Operational Cost

Cost item	Estimated annual cost in USD
Labour cost	25,000 to 35,000
Explosives and blasting	20,000 to 30,000
Fuel and maintenance	50,000 to 75,000
Transport and logistics	15,000 to 25,000
Administrative and other costs	10,000 to 15,000
Total estimated annual operational cost	120,000 to 180,000

The result in table 3 shows that fuel and maintenance would likely be the highest recurring operational cost. This is because quarry machinery such as excavators, haul trucks, crushers, and drilling machines consume large quantities of fuel and require regular servicing. Labour cost is also important, especially because skilled operators, blasters, mechanics, supervisors, and safety officers are needed for safe and efficient quarry operation. The implication is that the profitability of the proposed quarry will depend strongly on fuel management, machine maintenance, production planning, and reduction of idle machine time.

Result of Market Demand and Pricing Analysis

The market result shows that Abuja provides a favourable market for granite aggregate because of ongoing urban growth, housing development, road construction, and infrastructure expansion. The estimated selling price of granite aggregate in Abuja ranges from ₦4,500 to ₦5,800 per ton, depending on aggregate size, quality, transport distance, and market conditions.

Table 4: Projected Granite Aggregate Price Trend in Abuja

Year	Projected price range per ton	Main market driver
2025	₦4,200 to ₦5,500	Housing and private construction
2026	₦4,500 to ₦5,800	Government and private infrastructure projects
2027	₦4,700 to ₦6,000	Continued urban development

The result in table 4 suggests that the proposed quarry has a strong market opportunity if it can produce consistently and deliver aggregates at competitive prices. Abuja's construction sector creates steady demand for materials such as crushed stone, stone dust, gravel, and road base aggregates. The location of the proposed quarry in Waru community gives it a logistical advantage because it is close to construction zones within the Federal Capital Territory. This closeness may reduce transportation cost and improve competitiveness when compared with suppliers located farther away.

Result of Economic Viability Analysis

The economic analysis indicates that the proposed quarry is financially viable under the projected assumptions. The key financial indicators used are Net Present Value, Internal Rate of Return, payback period, and breakeven point.

Table 5: Projected Financial Viability of the Proposed Quarry

Financial indicator	Projected result	Interpretation
Net Present Value	₦120 million	Positive NPV shows that the project is financially viable
Internal Rate of Return	20 percent	IRR is above the 15 percent benchmark used for quarry viability
Payback period	3.5 years	Capital can be recovered within a reasonable period
Breakeven point	50,000 tons per year	Minimum annual production needed to cover cost

The result in table 5 shows that the proposed quarry can generate positive financial returns if production, sales, and cost assumptions are achieved. A positive NPV of ₦120 million means that the expected future cash inflows are higher than the initial investment when discounted to present value. The IRR of 20 percent also shows that the project is attractive because it is higher than the 15 percent benchmark mentioned in the study. The payback period of 3.5 years is acceptable for a quarry project because the business requires heavy initial capital for land, machinery, crushing plant, and infrastructure. The break even point of 50,000 tons per year means that the quarry must produce and sell at least 50,000 tons of granite aggregate yearly before it can begin to make profit.

Break Even Result

The break even analysis shows the minimum output required for the quarry to avoid loss. Based on the projected result, the quarry must sell 50,000 tons of aggregate per year to cover fixed and variable costs.

Table 6: Break Even Analysis

Item	Result
Average selling price	₦4,500 to ₦5,800 per ton
Projected break even output	50,000 tons per year
Production level below break even	Loss position
Production level above break even	Profit position
Financial implication	Quarry must maintain steady production and sales above 50,000 tons yearly

The result in table 6 implies that production planning is very important. If the quarry produces below 50,000 tons per year, it may not recover its operating costs. However, if production and sales rise above 50,000 tons per year, the quarry can begin to generate profit. Therefore, the proposed quarry should not only focus on production capacity but also on securing buyers such as construction companies, road contractors, block industries, concrete producers, and government project contractors.

Result of Environmental and Regulatory Assessment

The environmental and regulatory result shows that the proposed quarry can only operate sustainably if it complies with relevant Nigerian mining and environmental laws. The main expected environmental issues include dust emission, noise from blasting and crushing, vibration, land disturbance, loss of vegetation, and possible community concerns.

Table 7: Environmental and Regulatory Result

Issue	Expected impact	Recommended control measure
Dust emission	Air pollution and health risk	Water spraying and dust suppression
Noise and vibration	Disturbance to nearby residents	Controlled blasting and noise monitoring
Land degradation	Loss of vegetation and soil disturbance	Progressive land reclamation
Water pollution	Sediment runoff into drainage channels	Proper drainage and settling ponds
Community concerns	Complaints and possible conflict	Community engagement and compensation where necessary
Regulatory compliance	Requirement for legal operation	Mining licence, EIA approval and safety plan

The result in table 7 shows that environmental management is a major requirement for the success of the proposed quarry. Although the project has strong economic potential, poor environmental control could lead to community resistance, regulatory penalties, or suspension of operations. Therefore, the quarry should prepare an Environmental Impact Assessment, adopt dust control systems, ensure controlled blasting, provide worker safety equipment, and maintain a proper land reclamation plan.

Result of Equipment Setup and Machinery Used for Aggregate Production

The equipment setup for the proposed medium scale granite quarry was designed to follow the normal production sequence from rock blasting to final aggregate sizing. The major machinery considered for the production process included drilling machines, blasting accessories, excavators, wheel loaders, dump trucks,

jaw crusher, cone crusher, conveyor belts, vibrating screen, and stockpiling equipment. The production arrangement was planned to ensure that blasted granite rock is reduced progressively from large boulders into marketable aggregate sizes suitable for asphalt, concrete, block making, and road construction.

The first stage of the equipment setup was the drilling and blasting phase. Drilling machines were used to drill blast holes into the granite rock mass, while explosives and blasting accessories were used to fragment the rock into smaller pieces suitable for loading and crushing. Controlled blasting was considered necessary to produce good fragmentation, reduce the occurrence of oversized boulders, and improve the efficiency of the crushing plant. After blasting, excavators and hydraulic breakers were used where necessary to break oversized rocks that could not enter the jaw crusher directly.

The second stage was loading and haulage. After fragmentation, excavators and wheel loaders were used to load the blasted granite into dump trucks. The dump trucks then transported the blasted rock from the quarry face to the crushing plant. This stage was important because steady feeding of material into the crushing plant determines the overall production rate of the quarry. Poor loading and haulage arrangement may lead to idle crusher time, high fuel consumption, and reduced production efficiency.

The third stage was primary crushing using a jaw crusher. The jaw crusher was selected as the primary crusher because it is suitable for reducing large blasted granite boulders into smaller rock fragments. The jaw crusher received the blasted rock from the feeder and crushed it into intermediate sizes that could be handled by the secondary crushing system. This stage reduced the size of the granite and prepared it for further reduction by the cone crusher.

The fourth stage was secondary crushing using a cone crusher. The cone crusher was used to further reduce the material from the jaw crusher into smaller and more uniform aggregate sizes. The use of a cone crusher improved the shape and grading of the final aggregate products. This stage was important because the quality of aggregate used in concrete, asphalt, and road construction depends on proper size reduction and particle shape.

The fifth stage was conveying and screening. Conveyor belts were used to move the crushed granite from the jaw crusher to the cone crusher and from the cone crusher to the vibrating screen. The vibrating screen separated the crushed material into different sizes based on market requirements. Oversized materials were returned to the cone crusher for further crushing, while properly sized materials were directed to separate stockpiles. This closed production system helped to improve product uniformity and reduce material wastage.

Table 8: Equipment Setup and Function in the Proposed Quarry

Production stage	Equipment used	Function
Drilling-blasting	Drilling machine, explosives and blasting accessories	To drill blast holes and fragment the granite rock mass
Secondary breaking	Hydraulic breaker, excavator mounted breaker	To reduce oversized boulders before crushing
Loading	Excavator and wheel loader	To load blasted rock into dump trucks
Haulage	Dump trucks and tippers	To transport blasted rock from quarry face to crushing plant
Primary crushing	Jaw crusher	To reduce large granite boulders into smaller rock fragments
Secondary crushing	Cone crusher	To produce smaller and more uniform aggregate sizes
Conveying	Conveyor belts	To transfer materials between crushers and screening

		units
Screening	Vibrating screen	To separate crushed granite into different aggregate sizes
Stockpiling	Pay loader and stockpile area	To store finished products according to sizes

Table 9: Aggregate Products Produced from the Crushing and Screening Plant

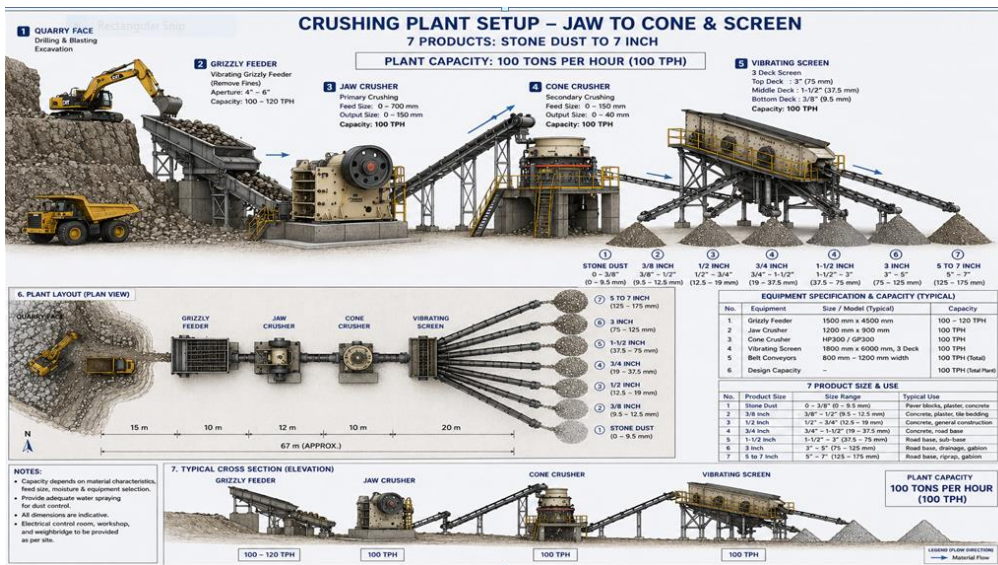
Product size	Major use
Stone dust	Asphalt production and block making
3/8 inch chippings	Block industry and asphalt production
1/2 inch chippings	Concrete and road construction
3/4 inch chippings	Concrete production
7/8 inch chippings	Concrete production
Stone base	Road construction before asphalt laying

The result in Tables 8 and 9 shows that the proposed equipment setup is suitable for producing different sizes of granite aggregate required in the Abuja construction market. The production line begins with drilling and blasting, followed by loading and haulage, primary crushing with a jaw crusher, secondary crushing with a cone crusher, conveying, screening, and stockpiling. This arrangement allows the quarry to produce stone dust, 3/8 inch chippings, 1/2 inch chippings, 3/4 inch chippings, 7/8 inch chippings, and stone base. These products are useful for asphalt production, block making, concrete works, road base preparation, and general civil engineering construction. The result further indicates that the jaw crusher and cone crusher are the most important machines in the crushing section because they determine the size reduction efficiency and quality of the final aggregate. The conveyor belts and vibrating screen are also essential because they ensure continuous movement and proper separation of materials. Therefore, the success of the proposed quarry will depend on proper selection, installation, operation, and maintenance of the crushing and screening equipment.



Figure 1 Conceptual Flowsheet of the Proposed Quarry

Figure 2 Developed Plant Layout of the Proposed Quarry



CONCLUSION AND RECOMMENDATION

The study evaluated the techno-economic viability of a proposed medium-scale granite aggregate quarry in Waru Community, Abuja, and established that the site possesses favourable geological conditions for granite production. The cost assessment revealed that the project requires significant initial investment in machinery, crushing facilities, haulage equipment, and infrastructure, while market analysis showed strong demand for granite aggregates due to continuous construction, housing, and road development activities in Abuja. The economic evaluation indicated that the project is financially viable, with a positive NPV of ₦120 million, an IRR of 20%, a payback period of 3.5 years, and a break-even production level of 50,000 tonnes per year. It was therefore recommended that detailed geological investigations, environmental impact assessments, and regulatory approvals should be completed before implementation. Additionally, efficient equipment management, proper maintenance practices, cost control strategies, and long-term supply agreements with construction companies and contractors should be adopted to ensure sustainable operation and improved profitability of the quarry project.

REFERENCE

1. Adeleke, A. O., & Adeyemi, O. G. (2020). Feasibility study and economic evaluation of granite quarry development in Northern Nigeria. *Journal of Mining and Geology*, 56(2), 145–156.
2. Alaba, O. A., & Agbalajobi, S. A. (2017). Economic assessment of granite quarry operations in Akure South Local Government Area, Ondo State, Nigeria. *International Journal of Engineering Research and Technology*, 6(8), 1–8.
3. Bilim, C., Atis, C. D., Tanyildizi, H., & Karahan, O. (2017). Predicting the compressive strength of ground granulated blast furnace slag concrete using artificial neural network. *Construction and Building Materials*, 22(10), 1906–1911.
4. Dvořáček, J., Šancer, J., & Vondráček, M. (2025). Economic evaluation and optimization of quarry operations: Factors affecting profitability and production efficiency. *Mining, Metallurgy & Exploration*, 42, 1–15.
5. Melodi, M. M., Onipede, O. A., & Oluwafemi, O. (2020). Cost analysis of granite quarrying operations in Nigeria: Implications for production efficiency and profitability. *Journal of Sustainable Mining*, 19(3), 145–15
6. Oshim, I. O., Eze, C. L., & Nwankwo, C. A. (2024). Environmental impacts and sustainability challenges of quarrying activities in Nigeria: A review. *Environmental Challenges*, 14, 100789.
7. United States Geological Survey (USGS). (2007). Crushed Stone and Sand and Gravel: Mineral Commodity Summaries. U.S. Geological Survey, Reston, Virginia.