Strategic Value of Marble Mine Management for Community Economic Improvement and Challenges Keeping Sustainable Environmental Support in Tulungagung Regency

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Abstract. Tulungagung Regency is famous as a marble producer. The utilization of marble resources in Tulungagung has been ongoing since the discovery of the location of a marble mine by the Dutch East Indies government in the 1934s. Over time, more and more companies have joined in setting up marble mines in Tulungagung Regency, especially in Besole Village. The major impact of the marble mines, which is the reduction in natural resources that cannot be renewed. Therefore, although this activity is one step to improve the quality of life to be able to compete. However, this activity is one step towards a resource crisis. The purpose of this study: (1) knowing the management of marble mines to improve the economy of the Tulungagung community, (2) knowing the types of management of marble mines in Tulungagung (3) knowing the challenges of preserving the environment sustainably in the former marble quarry area. This study uses a qualitative method with a case study approach. The collected data were analyzed using triangulation techniques. The results showed that mining in the study area has strategic value to improve the community's economy. The types of community activities in mining management include miners, calcium processors, dolocytes processors, marble processors (block cutting, cross-cutting, calibrating, putty, polishing), and marketing. The challenge of maintaining environmental sustainability is to integrate ethical business practices and environmental preservation.

1. Introduction
Uncontrolled population growth forces economic growth such as industry to balance it because population growth is followed by demand growth [30]. However, the industri growth program run by the Indonesian government has not been able to improve people's welfare.

Industrial growth is an effort to improve the welfare of a country and society [33]. This has been taken since the end of the Dutch East Indies government colonialism in Indonesia. Besides, to process Indonesia's abundant resources compared to foreign countries that have occupied Indonesian territory. Meanwhile, the first industry developed by the Dutch East Indies was a textile factory [38]. This activity is also supported by Indonesia's abundant forest resources and contains various resources, both renewable and non-renewable. Meanwhile, the recorded forest area in Indonesia is around 125.9 million hectares [14]. Therefore, the activity of exploiting natural resources for the industry has great potential to improve community welfare.

Indonesia's natural resources are also a great opportunity for stakeholders to improve the welfare of the community [24]. This is because the land and water and the natural resources contained therein are controlled by the state and used for the greatest prosperity of the people [41]. Therefore, many industrial estates have sprung up that exploit the wealth of natural resources. One of them is the mining area as one of the supporting factors for economic growth and regional development.

Mining is one of the activities to utilize natural resources as a fulfillment of needs. Economic pressure in developing countries has made the mining business one of the ways to pay off foreign debts because mining is claimed to provide the largest contribution to state revenue during 2018 [6].

Mining activities, on the other hand, harm the environment. The main impact given by mining is on environmental damage and the reduction of non-renewable natural resources [18]. This impact is obtained from mining operations that do not pay attention to the sustainability of the resource itself.
Therefore, although this activity is one step to improve the quality of life to compete. However, this activity is one step towards a resource crisis. Wiyono [40] explains that an environmental economic instrument is a set of economic policies to encourage the government, regional government, or everyone towards the preservation of environmental functions.

One area that utilizes natural resources through mining is Tulungagung Regency, East Java Province. This regency is known as a marble producer from its mining activities. Tulungagung Regency is often referred to as the City of Marble. This is supported by extensive karst mountain ranges as a center for marble mining. As for the 2012-2032 Tulungagung Spatial Plan, there are approximately 12,334 hectares of karst areas in Tulungagung[28]. Tulungagung is located in the southern mountainous route which, according to the Provincial Government of East Java, is formed from limestone and igneous intrusion and lava flows, has marble potential [28]. One of the marble mining centers in Tulungagung is located around Besole Village, Besuki district [17].

The use of marble resources in Tulungagung has been going on since the discovery of a marble mine by the Dutch East Indies government in the 1934s. The time goes, more and more companies are involved in establishing marble mines in Tulungagung Regency, especially in Besole Village. It is estimated that there are more than 2500 business units engaged in marble mining in Besole and Gamping Villages [13]. Although according to [8] the rate of mineral supply on the southern coast of Indonesia is intensive, the increase in miners is assumed to cause an increase in mining activity as well. So, this activity is assumed to make the existing marble resources in Tulungagung Regency increasingly depleted.

To maintain the sustainability of marble resources, one way that can be used is to maintain the carrying capacity of the environment in sustainable regional development. This is in accordance with the pillars of sustainable environmental development that ensures sustainable production patterns [2]. This can be done in various ways, as will be explained in this article. Therefore, the purpose of writing this article is to find out ways that can be done in maintaining the carrying capacity of the mining environment as an effort to develop areas with a sustainable concept.

2. Methods
This study uses a qualitative method with a case study approach to achieve its objectives. This is because this approach can reveal in detail and complete the phenomenon or case being studied [4]. In qualitative research, the presence of the researcher is necessary, because the researcher is a data collection instrument. The researcher, in this case, plays a role in the entire research process, both as a planner, implementer of data collection, analyzer, data interpreter, and ultimately as a reporter of the research results [23].

The location of this research is in Besole Village, Besuki district, Tulungagung Regency. This area is an area where there is a lot of marble mining [28]. Is because in the region there are mixed land formations. This formation consists of crystal limestone inserted with carbonaceous clay, some of the limestones have been tared, pyrited, and mineralized manganese (Mn) due to breakthrough igneous rock [10]. This village is also a place for processing marble mining products.

The primary data source of this research was obtained directly from the results of interviews and observations conducted by researchers. Meanwhile, secondary data is obtained from documentation studies from various literature including journals, scientific articles, websites, and document or archive data from various sources that support the research. The selection of data sources in this study uses snowball techniques to make it easier for researchers to find accurate and in-depth information to achieve research objectives. This is because of the increasing number of data sources will be able to provide satisfactory answers to achieve the research objectives [36]. Meanwhile, to collect data, researchers directly met the parties who could provide information and data regarding this research.

Data collection activities were carried out in three ways, namely: observation, interviews, and documentation. Observation is one of the data collection techniques to obtain information by observing both actors, activities, and activities, which is followed by recording activities [42]. The interview is a dialogue conducted by interviewers to obtain information from the interviewee or informant [1]. In conducting interviews, the researcher tries to do it in-depth with the informants by forming two kinds of questions, namely substantive and theoretical questions. Substantive questions are in the form of specific issues related to mining activities, management, and the form of reclamation of ex-mining. Meanwhile, theoretical questions are related to meaning and function. Sugiyono [36]
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explanan that documentation is a record of events that have passed, documents can be in the form of writings, pictures, or monumental works. Documentation studies are carried out to complement the results of interviews and observations in research.

The data analysis process was carried out in two stages, namely (1) pre-field analysis and (2) field data analysis. The data analysis stage before going to the field was carried out using preliminary observations and determining secondary data to determine the focus of the research. The data analysis phase in the field was carried out using an interactive model. This data analysis model emphasizes data analysis which is carried out interactively and continues to completion until the data is saturated [22]. This analysis model has three steps, namely data reduction, data presentation, and concluding.

The validity of the data in this study used an internal validity test through a credibility test. This is done so that the results can be accounted for. This check is carried out because the main instrument in qualitative research is humans. Thus, it is necessary to hold a credibility test to increase confidence in the findings of this study. In this study, the credibility test was carried out by triangulating the data. Data triangulation is an effort to check data by combining data from various sources and in various ways and times [36].

3. Results and Discussion

3.1. Economic Improvement through Mining Management

Tulungagung is one of the regencies that has abundant natural resource potential, especially minerals. Mining materials are one of the natural resources that have a significant role in the continuity of national development [21]. Therefore, natural resources in the form of minerals in their processing are controlled by the state and used for the greatest prosperity of the people [41]. Thus, economic improvement as one of the indicators of prosperity is also assumed to increase from exploration and processing of minerals through mining.

One of the minerals that have developed by Tulungagung is marbles. This is because the southern line of Tulungagung mountains is dominated by karst topography where marble is formed. There are approximately 12,334 hectares of karst areas in Tulungagung [28]. Marble also has a large market opportunity as a material for making tiles and decorations both at home and abroad. Marble waste can even be used as a building material. This is evidenced by research [31] which shows that the addition of marble waste to the concrete mixture can reduce the absorption value, increase the compressive strength, and increase the elasticity module of the concrete.

The potential of marble which can penetrate the global and mondial market has made marble an alternative to face the worsening business environment in Indonesia due to the economic crisis. This is because marble mining production can provide economic benefits to local communities with its ability to absorb labor and provide opportunities for the emergence of new businesses around the mining area [7]. Therefore, there is a need for efficient and maximum profit-oriented production.

The production orientation in the economy is always directed at obtaining maximum profit. The producers have a similar orientation to consumers, namely satisfaction in buying and selling transactions, but producers measure their satisfaction in the form of profit [5]. To obtain maximum profit, the remaining marble production waste can also be processed and utilized. As for Tulungagung, marble production waste can be reprocessed into dolosit and calcium.

Dolosit is waste in the form of a powder that comes out of processing marble stones into marble products. Almost all of the marble processing activities use the help of water, making the waste in the form of this powder dissolve and flow with the water to a reservoir. If this powder is only deposited in a reservoir, over time it will harden and can pollute the environment. This waste can be used so that it does not pollute the environment and has economic value. Dolosit can be used as a mixture of building materials for bricklaying, plastering of basic walls, plastering smooth walls.
Calcium is a substance commonly found in rocks in all parts of the world. Calcium has several distinctive properties, including reacting with strong acids. Calcium releases carbon dioxide on heating to form calcium dioxide which is usually called lime. Therefore, limestone as the residual of marble production has a lot of calcium carbonate content ([25]. So therefore, by processing the remaining gravel from marble production, calcium flour can be obtained which can be used to whiten walls.

Ministry of Agriculture of the Republic of Indonesia [15] explains that utilization of the waste from the marble production basically can also control the environmental impact of mining. Is because they both contain a lot of lime in them. The excessive lime content in the soil will cause the soil to lack nutrients that are beneficial to plants. In addition, if it is in water it will also cause interference in terms of usage. In fact, the requirement for clean water is that it does not contain chemicals that can interfere with both the use and health aspects [34].

3.2. Types of Marble Mine Management in Tulungagung
Managing marble stones (blocks) to produce marble tiles and waste in powder form goes through several stages. These stages start from (1) marble mining, (2) marble processing, (3) production supervision and quality control, and (4) marketing. The explanation of the stages is as follows.
3.2.1. Marble Stone Mining

![Marble Mining Process](image1)

**Figure 3.** Marble Mining Process  
Source: [16]

Mining is an activity to produce minerals and associated minerals [14]. Meanwhile, marble as a mining product is obtained by cutting the limestone mountain (Figure 3). This is because marble is in the mountains and surrounded by limestone [29]. The result of this activity is marble slabs which can then be processed and produce processed marble products.

![Marble Quarry](image2)

**Figure 4.** Marble Quarry  
Source: [16]

![Marble Block Weighing](image3)

**Figure 5.** Marble Block Weighing  
Source: [16]

The marble blocks are then transported to the processing plants by truck. Therefore, the most important parties associated with this activity are the miners who cut the limestone mountain into chunks of marble.

3.2.2. Marble Processing

After the marble blocks arrive at the processing site, there are several stages to process the production of processed marble products. The processes according to [16] are (1) block cutting, (2) cross-cutting,
(3) calibrating slab, (4) putty, (5) polishing, (6) cross-cutting size. The explanation of the relationship is as follows.

Block cutting is an activity to cut marble blocks into slabs (slabs of marble stone). Furthermore, the slab sheet is cut at the edges to flatten the edges (cross-cutting). The calibrating process is carried out to cut to the desired size and flatten one surface. The part that still has small holes is then caulked before polishing. Polishing is an activity to smooth the surface after the slab is putty. Of all these activities, a marble tile product is ready to be installed or what is called a marble slab type [12]. However, to meet market needs there is another stage to cut marble as needed. Cutting at this final stage is usually referred to as a cross-cutting size. The results of this activity are commonly referred to as cutting types of marble with varying sizes, according to consumer tastes and needs [12].

![Figure 6. MarbleBlockCuttingProcess](image1)
Source: [16]

![Figure 7. CalibratingProcess](image2)
Source: [16]

![Figure 8. Putty Process](image3)
Source: [16]
Marble processing activities are greatly assisted by water. As for the cutting stage, water is used to cool the cutting edge of marble [39]. Meanwhile, in polishing, water is used to facilitate and smooth the surface of the stone, and to display the stone fibers [9]. The water will bring the marble waste powder from the two processes to the reservoir. As for the reservoir, the dolosit are collected before they can be taken and used.

Judging from the processing above, it can be seen that there are several parties involved in the process. The parties involved are marble processing, dolosit processor, and calcium processor.

3.2.3. Production Supervision and Quality Control
To maintain the highest quality. At this stage, a well-defined set of procedures is established to coordinate labor, raw materials, and machinery to ensure maximum production efficiency. Therefore, (1) production planning, (2) scheduling, and (3) production arrangements are important. The explanation is as follows.

Production planning is a stage in which the amount of resources (including raw materials and other components) is determined which the company needs to produce certain outputs. In this process, a list of raw materials contains all the necessary ingredients based on past data and some future assumptions [24]. This activity is also to determine the operating budget and labor requirements [33]. Next is scheduling which is an activity to create a schedule that contains how long each operation in the production process takes place and when the worker must carry it out. Efficient scheduling ensures that production will meet delivery schedules and make efficient use of resources. This is because scheduling also includes the allocation of power, production machines and equipment, process sequences, product types, and the purchase of materials [26], [20]. While the arrangement, namely the production control stage which contains the instructor manager of each department, regarding the work to be done and the time required for completion. To create products with constant quality and even tend to increase, one of the ways needed is to establish Standard Operating Procedures (SOPs). The SOPs describe the steps that must be taken in a department [35].

Basith [3] explains that quality control involves measuring the output against a predetermined quality standard. The way to monitor the quality level is from the output that has been produced, one
of which is through the results of a survey of customers. This is because the survey results from customers will show customer satisfaction with the products that have been produced. Customer satisfaction with the resulting product affects loyalty.

How to monitor the quality can also be based on the quality of the materials used in manufacturing. The quality of materials that are extracted in Tulungagung is as follows.

### Table 1. Mineral Resources in Tulungagung Regency, East Java Province

| No | Minerals | Location | Resource | Quantity | Quality  |
|----|----------|----------|----------|----------|----------|
| 1  | Mangan  | Sukorejo&TenggongRejotangan District | Tereka | 500 tonore | 34,24-41,43% Mn |
|    | Mangan  | Trenggalek, Tulungagung Besuki&WatulimoDistrict | Tereka | 215 tonore | 84,06% MnO2 |
| 3  | Mangan  | Tulungagung, BandungDistrict | Terunjuk | 45.000 tonore | 47,9% Mn |
| 4  | Marble  | Besole, BesukiDistrict | Terunjuk | 9.855.000 tonmetal | 34,24-41,43% Mn |
| 5  | Marble  | G. Kuncung,KalidawirDistrict | Tereka | 351.000 tonore | 84,06% MnO2 |
| 6  | Sirtu    | KaumanDistrict | Hipotetik | 22.000 ton | 47,9% Mn |
| 7  | Besi (Fe) | Ngipik, Klumpit& Kemiri; KalidawirDistrict | Terukur | 50-ton ore | - |

Source: [10]

By knowing the quality of the materials used, the processing process will be determined to maintain the quality of the products produced (raw material control) [32].

### 3.3. Challenges in Managing Sustainable Environmental Carrying Capacity

Mining activities can harm the environment. Uncontrolled mining activities can cause environmental damage and pollution [2]. In fact, with the damage to the environment, it can cause the ecosystem in the mining area and its surroundings to be damaged. Ecosystem damage is an ecosystem condition that can no longer perform its functions optimally, such as soil protection, water management, weather control, and other functions in regulating nature protection [18]. Meanwhile, in Law Number 32 the Year 2009, environmental damage is a direct and/or indirect change to the physical, chemical, and/or biological characteristics of the environment that exceeds the standard criteria for environmental damage. In Tulungagung Regency, natural damage is mostly caused by mining activities, especially marble. Marble mining activities in Tulungagung have caused large holes and caused the loss of vegetation that can absorb water.

Tulungagung is famous for its marble industry with thousands of marble quarries. However, only a few of the thousands of marble miners in Tulungunga have mining permits. According to information from the Public Works Department of Energy and Mineral Resources (PUESDM), only 39 miners have permits. This shows that there are still many illegal marble miners in Tulungagung. For example, in the Campurdarat and Besuki regions, it is estimated that there are hundreds of miners, both large and small. Not to mention mining activities in any other districts, as well as other types of rock mineral excavation [37]. Various writings relating to illegal mining show that mining activities always harm the environment. Therefore, this condition is very worrying about the sustainability of the environment, especially the karst ecosystem in Tulungagung.

Even though it has bad influence on the sustainability of the ecosystem, mining has a positive effect on economic activity. Mining can contribute to increasing local revenue, open up regional isolation, contribute to foreign exchange, create jobs, support the procurement of goods and services for consumption, support production activities, and can provide infrastructure for the growth of other economic sectors [19]. In depth, [7] revealed that mining sector can have a positive influence on the national and local economies, especially on the communities around the mine. These influences start
from (1) providing added value to national economic growth, (2) increasing local revenue, (3) accommodating labor (4) increasing the economy of the community around the mine, (5) increasing local community micro-businesses around the mine, (6) improve the quality of human resources for local communities around the mine, and (7) improve the health status of local communities around the mine.

Seeing the advantages and disadvantages of maintaining the mining industry, implementing ethical industrial practices, and environmental preservation to maintain environmental sustainability is a challenge in implementing mining development in Tulungagung. This is because, the higher the human activity to achieve GNP (Gross National Product), the heavier the effort that must be made to manage a prime environmental quality environment [34]. Therefore, the [11] has compiled ten principles of sustainable mining management as follows: (1) implement ethical business practices & good and transparent corporate governance to support sustainable development; (2) integrate the principles of sustainable development in the company's strategy and decision-making process; (3) respect for human rights and interests, culture, customs, employees, and community values that are built up by mining activities; (4) implementing an effective risk management strategy and system based on valid and scientific data; (5) continue to improve performance in health and safety; (6) continuously enhancing improvements in environmental performance; (7) contribute to biodiversity conservation and integrated approaches to spatial planning; (8) facilitating and supporting the design of production, use, reuse, recycling, and disposal of products responsibly containing metals and minerals; (9) contribute to the social, economic, and institutional development of the community around the operational area; and (10) involve stakeholders proactively, transparently, and openly regarding the challenges and opportunities of sustainable development.

4. Conclusions
Based on the discussion, it can be concluded that: First, the geological structure in Tulungagung Regency causes a large amount of mineral content and a large enough potential forming mining products in Tulungagung. Marble is one of the mining products that have been developed and provides additional revenue for the Tulungagung Regency. This is because all the products of marble mining can be utilized and have economic value, both the processed products and the resulting waste. Second, the processing of marble blocks into marble products through several stages, namely (1) marble mining, (2) marble processing, (3) production control and quality control, and (4) marketing. Therefore, the parties involved include (1) marble miners, (2) marble processors, (3) dolostic processors, (4) calcium processors, and (5) production and marketing managers. Third, marble mining activities have a good effect on economic growth. However, this activity has a labor impact on environmental sustainability. Therefore, the challenge of maintaining environmental sustainability is to integrate ethical business practices and environmental preservation.

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