

Alternatives selection to control the impact of unlicensed sand mining at Batur Global Geopark using Analytical Hierarchy Process

K.M. Ricky Rinaldy^{1*}, Ninasapti Triaswati¹, Dwi Nowo Martono¹
¹*School of Environmental Science, Universitas Indonesia*

Abstract: Based on the problem of unlicensed sand mining at the Batur Global Geopark, research is needed on controlling the impact of unlicensed sand mining in terms of environmental, social, and economic dimensions, in the Batur Global Geopark area. This study uses the analytical hierarchy process (AHP) method to choose alternative impact control on illegal sand mining at Batur Global Geopark. This study uses assessments from 12 stakeholders. The five AHP criteria in this study are; Increase people's income; Contribute to regional development tax; Simplify the mining permit process; Increase other job opportunities; Minimize the risk of environmental damage; and Repairing environmental damage; while the three alternatives in this study are; Partnership program; Granting community mining permits with relatively simple concepts and obligations; and Closing and providing sanctions in accordance with law. The highest weight of the overall value of all criteria is the partnership program.

Keywords: unlicensed sand mining, Batur Global Geopark, analytical hierarchy process

Introduction

Mining activities provide great and promising opportunities for the development of a region. The mining industry itself is one of the industries that the Indonesian government relies on to bring prosperity (Awan and Mulya, 2020; Madyise, 2013). Indonesia is a country that is rich in natural resources, be it coal, gold, copper, nickel, bauxite and is also one of the mineral mining commodities in Indonesia, namely sand.

The need for sand continues to increase in direct proportion to development (Dubiński, 2013), this is a global problem because it accommodates the needs of urban population growth and industrialization (Dewi *et al.*, 2019). Basically, development is an effort to make changes that are planned consciously and sustainably for a better purpose (Yandra, 2016). Economic growth in meeting the needs and desires of today's development should not sacrifice the fulfillment of future needs (Karuniasa, 2016), which we know as the concept of sustainable development. There are still unlicensed sand mining activities, threatening the protected area of Batur Global Park which has entered the era of regional development (Hermawan and Brahmanto, 2018; Nurjani and Firdiyansyah, 2020). The identification results based on satellite imagery show that there are indications of several locations where illegal sand mining is located.

On the other hand, mining activities in the area provide a high amount of income when compared to other jobs, thus making mining players reluctant to switch sectors. This then has an impact on the tourism sector which is getting worse along with the quality of the environment due to a lack of understanding from the community about the concept of sustainable development so that it affects several other sectors (Gorey *et al.*, 2016). Economic activities affect the environment, and environmental changes affect the economy and the environment is considered as two systems that are interdependent on each other (Goleman, D *et al.*, 2012; Liu *et al.*, 2018).

The need for economic fulfillment with the growing human population is supported by increasingly sophisticated technological developments, greatly affecting the environment as life support services and amenity services such as the Batur Global Geopark protected area. The main purpose of the Batur Global Geopark is to balance geology, environment, social - culture, economy, and conservation. Geoparks have three main objectives, namely protection and conservation, infrastructure development and socio-economic development so that they are expected to attract tourists which in turn will have a development impact on local governments and communities, Batur Global Geopark is the first geopark in Indonesia to be recognized by UNESCO (Arcana and Wiweka, 2016). Based on the previous explanations, the sustainability of the Batur Global Geopark needs to be maintained in order to maintain good economic, social, historical, and environmental values.

In recent years, there has been sand mining in the Batur Global Geopark area, unlicensed sand mining activities contradict the objectives of the Batur Global Geopark and create environmental and infrastructure problems (Rosyidie *et al.*, 2018). Mining activities using machines and heavy equipment that make noise disturb the comfort of the surrounding community and worsen air quality (Wiguna *et al.*, 2017), the roads at this time are still in very poor condition caused by excavations, trucks which are loaded with sand and stones, do not yet

have a special route which causes the routes in the area to quickly deteriorate and even interfere with the journey of tourists because they have to pass on roads that are still traversed by trucks carrying materials, so a lot of dust is scattered (Wendita, 2019). This shows that the existence of sand mining is a challenge for the sustainability of the Batur Global Geopark.



Figure 1. Abandoned sand mining area in the Batur Global Geopark area

Unlicensed sand mining continues to increase in direct proportion to the need for sand commodities for development. In addition to the positive impact, sand mining activities carried out without the application of good mining engineering principles (Good Mining Practices) could have a negative impact on the social, economic, and environmental dimensions (Sugiarta and Suharta, 2018). One of these activities took place in the protected area of Batur Global Geopark, thus threatening its status as the first Global Geopark in Indonesia recognized by UNESCO. Government regulations from the regional to the central level have been issued, however, illegal sand mining is indicated to still be found. Based on the problem of unlicensed sand mining at the Batur Global Geopark, research is needed on controlling the impact of unlicensed sand mining in terms of environmental, social, and economic dimensions, in Batur Global Geopark area. Therefore, it is needed a sustainable alternative that is socially acceptable, economically feasible, and good for the environment, this study uses the analytical hierarchy process (AHP) method to choose alternative impact control on illegal sand mining at Batur Global Geopark.

Method

The working principle of the AHP method is to simplify a complex and unstructured problem into elements that are neatly arranged in a hierarchy (Marimin, 2004). The level of importance of each variable is then assigned a numerical value which indicates the importance of the variable compared to other variables. Based on various considerations, a synthesis was carried out to determine the variables with higher priority that could affect the results of the system.

AHP allows users to assign values or relative weights of an attribute, sub-attribute or alternative factor according to the user's perception of the factor by doing pairwise comparisons (Lolli *et al.*, 2014; Huang and Gou, 2019; Saaty, 1989). Furthermore, the pairwise comparison is converted into a collection of numbers that represent the relative priority of each attribute, sub-attribute and alternatives. If there is a deviation that is too far, the assessment needs to be corrected or the hierarchy must be rearranged.

The advantages of the AHP method in decision making according to Suryadi and Ramdani (2002) are:

1. Able to solve complex problems whose structure is irregular or not structured at all.
2. The incompleteness of the written data or quantitative data of the problem does not affect the smoothness of the decision-making process because the assessment is based on the synthesis of the thoughts of the respondent's point of view
3. In accordance with the human ability to provide an assessment of something so that the assessment and measurement of elements becomes easier
4. Equipped with a consistency test so as to guarantee the decisions that have been determined

The weaknesses of the AHP method (Sen, 1998) are:

1. Cannot be applied if there is a very extreme difference in point of view between respondents
2. Respondents involved must have knowledge and experience enough about the problems and methods of AHP

The five AHP criteria in this study are:

- Increase people's income
- Contribute to regional development tax
- Simplify the mining permit process
- Increase other job opportunities
- Minimize the risk of environmental damage
- Repairing environmental damage

while the three alternatives in this study are:

- Partnership program
- Granting community mining permits with relatively simple concepts and obligations
- Closing and providing sanctions in accordance with Law

This study uses assessments from 12 stakeholders from researchers, miners, and the government.

Result and Discussion

The selection of alternative solutions is carried out to control the impact of unlicensed sand mining at Batur Global Geopark, this starts with weighting the criteria.

Table 1. Criteria weighting

	Increase people's income	Contribute to regional development tax	Simplify the mining permit process	Increase other job opportunities	Minimize the risk of environmental damage	Repairing environmental damage
Increase people's income	1	2 1/4	3 1/2	4 4/9	1 7/9	1 5/7
Contribute to regional development tax	4/9	1	3/4	2 1/4	1 1/6	1 1/5
Simplify the mining permit process	2/7	1 1/3	1	5 7/9	3 5/6	3 3/5
Increase other job opportunities	2/9	4/9	1/6	1	4	4 1/5
Minimize the risk of environmental damage	5/9	6/7	1/4	1/4	1	3
Repairing environmental damage	3/5	5/6	2/7	1/4	1/3	1
Total	3 1/9	6 2/3	6	14	12 1/7	14 2/3

From the results of the weighting of the criteria, it was found that the most significant criterion was to increase the income of the community, the results of the weighting of the criteria also had a consistency ratio of 0.23. The next step is to calculate the weight of each aspect of each criterion

Table 2. Priority towards increasing people's income

	Partnership program	Granting community mining permits with relatively simple concepts and obligations	Closing and providing sanctions in accordance with law
Partnership program	1	3 4/7	4 1/4
Granting community mining permits with relatively simple concepts and obligations	2/7	1	4 1/3
Closing and providing sanctions in accordance with law	1/4	1/4	1
Total	1 1/2	4 4/5	9 5/9

On the criteria for improving the community, the alternative that has the highest weight is the partnership program with a consistency ratio of 0.16.

Table 3. Priority towards contributing regional development taxes

	Partnership program	Granting community mining permits with relatively simple concepts and obligations	Closing and providing sanctions in accordance with law
Partnership program	1	4	4 1/2
Granting community mining permits with relatively simple concepts and obligations	1/4	1	4 3/8
Closing and providing sanctions in accordance with law	2/9	2/9	1
Total	1 1/2	5 1/5	9 6/7

On the criteria for contributing to regional development taxes, the alternative that has the highest weight is the partnership program with a consistency ratio of 0.18.

Table 4. Priority towards simplify the mining permit process

	Partnership program	Granting community mining permits with relatively simple concepts and obligations	Closing and providing sanctions in accordance with law
Partnership program	1	3 4/5	4 1/3
Granting community mining permits with relatively simple concepts and obligations	1/4	1	4 4/5
Closing and providing sanctions in accordance with law	1/4	1/5	1
Total	1 1/2	5	10 1/9

On the criteria to simplify the mining licensing process, the alternative that has the highest weight is the partnership program with a consistency ratio of 0.2.

Table 5. Priority towards increasing other job opportunities

	Partnership program	Granting community mining permits with relatively simple concepts and obligations	Closing and providing sanctions in accordance with law
Partnership program	1	4 1/5	4 1/2
Granting community mining permits with relatively simple concepts and obligations	1/4	1	4
Closing and providing sanctions in accordance with law	2/9	1/4	1
Total	1 1/2	5 1/2	9 1/2

On the criteria of increasing other job opportunities, the alternative that has the highest weight is the partnership program with a consistency ratio of 0.16

Table 6. Priority on minimizing the risk of environmental damage

	Partnership program	Granting community mining permits with relatively simple concepts and obligations	Closing and providing sanctions in accordance with law
Partnership program	1	3 5/7	4
Granting community mining permits with relatively simple concepts and obligations	1/4	1	4
Closing and providing sanctions in accordance with law	1/4	1/4	1
Total	1 1/2	5	8 7/8

In the criteria of minimizing the risk of environmental damage, the alternative that has the highest weight is the partnership program with a consistency ratio of 0.17.

Table 7. Priority towards repairing environmental damage

	Partnership program	Granting community mining permits with relatively simple concepts and obligations	Closing and providing sanctions in accordance with law
Partnership program	1	4	3 4/5
Granting community mining permits with relatively simple concepts and obligations	1/4	1	3 5/8
Closing and providing sanctions in accordance with law	1/4	2/7	1
Total	1 1/2	5 1/3	8 3/7

In the criteria for repairing environmental damage, the alternative that has the highest weight is the partnership program with a consistency ratio of 0.18.

The last step of determining the best alternative is to calculate the overall value of the priority alternative solutions as shown in the following table.

Table 8. Overall value priority alternative solution

	Increase people's income	Contribute to regional development tax	Simplify the mining permit process	Increase other job opportunities	Minimize the risk of environmental damage	Repairing environmental damage	Combination score
Partnership program	0.615748543	0.632443445	0.61773921	0.644558167	0.614384227	0.624071966	0.622962864
Granting community mining permits with relatively simple concepts and obligations	0.281316895	0.268632354	0.283622422	0.254576975	0.275160011	0.260975047	0.274160012
Closing and providing sanctions in accordance with law	0.102934562	0.098924202	0.098638368	0.100864859	0.110455762	0.114952987	0.102877124
Total	1	1	1	1	1	1	1

From the table above, it can be concluded that the highest weight of the overall value of all criteria is the partnership program, this result is obtained because of the views of various stakeholders who want to preserve the mining activity but still want to preserve the existing environment, this is in line with other studies that use the AHP method to see green mines (Wu *et al.*, 2022).

However, in this study the overall value of the consistency ratio is 0.1, this happens because of differences in the assessment on the basis of interests from the different stakeholders. With the consistency ratio value above 0.1, other studies suggest that the AHP method should be optimized to reduce the consistency ratio (Moussaoui *et al.*, 2018; Lukinskiy *et al.*, 2021).

Conclusion

From this research, the conclusions that can be drawn are:

1. The most significant criterion was to increase the income of the community
2. The highest weight of the overall value of all criteria is the partnership program

Recommendations that can be given to overcome this problem in the next research is to use fuzzy AHP, this method is able to give more freedom to experts to express their judgments, increasing the number of stakeholders could also be a recommendation for similar research in the future for better result.

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References

- [1]. Arcana, K., & Wiweka, K. (2016). Educational tourism's product strategy at batur global Geopark, Kintamani-Bali. In *Asia Tourism Forum 2016-the 12th Biennial Conference of Hospitality and Tourism Industry in Asia* (pp. 316-322). Atlantis Press.
- [2]. Awan, F. N., & Mulya, M. B. (2020). Faktor Penyebab Konflik Sosial Masyarakat Pesisir Penambangan Pasir Laut Di Pantai Labu Kabupaten Deli Serdang. *Jurnal Niara*, 13(1), 252-259.
- [3]. Dewi, I. K., Susilawati, S., & Raf, N. (2019). Implementation of environmental management policies on the impact of illegal sand mining. In *IOP Conference Series: Earth and Environmental Science* (Vol. 343, No. 1, p. 012129). IOP Publishing.
- [4]. Dubiński, J. (2013). Sustainable development of mining mineral resources. *Journal of Sustainable Mining*, 12(1), 1-6.
- [5]. Goleman, D., Bennett, L., & Barlow, Z. (2012). *Ecoliterate: How Educators are Cultivating Emotional, Social, and Ecological Intelligence*. San Francisco: Jossey Bass
- [6]. Gorey, P., McHenry, M., Morrison-Saunders, A., Mtegha, H., & Doepel, D. (2016). Critical elements in implementing fundamental change in public environmental policy: Western Australia's mine closure and rehabilitation securities reform. *Australasian Journal of Environmental Management*, 23(4), 370–381.
- [7]. Karuniasa, M. (2016). *Holistic Approach in Practice: The Principles of National Sustainable Development System*. School of Environmental Science. Jakarta: Universitas Indonesia.
- [8]. Hermawan, H., & Brahmanto, E. (2018). *Geowisata: Perencanaan Pariwisata Berbasis Konservasi*. Penerbit NEM.
- [9]. Huang, H., & Guo, X. (2019). The Evaluation model for the departure audit of mineral resources for leading cadres based on AHP method. In *2019 International Conference on Economic Management and Model Engineering (ICEMME)* (pp. 364-367). IEEE
- [10]. Liu, Y., Li, J., & Yang, Y. (2018). Strategic adjustment of land use policy under the economic transformation. *Land Use Policy*, 74, 5-14.
- [11]. Lolli, F., Ishizaka, A., & Gamberini, R. (2014). New AHP-based Approaches for Multi-Criteria Inventory Classification. *Int. J. of Production Economics*, 156, 62–74.
- [12]. Lukinskiy, V., Lukinskiy, V., Sokolov, B., & Bazhina, D. (2021, September). An Empirical Examination of the Consistency Ratio in the Analytic Hierarchy Process (AHP). In *IFIP International Conference on Advances in Production Management Systems* (pp. 477-485). Springer, Cham.
- [13]. Madyise, T. (2013). *Case studies of environmental impacts of sand mining and gravel extraction for urban development in Gaborone* (Doctoral dissertation, University of South Africa)
- [14]. Marimin. 2004. *Teknik dan Aplikasi Pengambil Keputusan Kriteria Majemuk*. Jakarta: PT.Gramedia Widiasarana Indonesia
- [15]. Moussaoui, F., Cherrared, M., Kacimi, M. A., & Belarbi, R. (2018). A genetic algorithm to optimize consistency ratio in AHP method for energy performance assessment of residential buildings— Application of top-down and bottom-up approaches in Algerian case study. *Sustainable Cities and Society*, 42, 622-636.
- [16]. Nurjani, N. P. S., & Firdiyansyah, A. (2020). Landasan Pembentukan Spasial Kawasan Taman Bumi Global Batur (Batur Global Geopark, Kintamani, Bangli, Bali). *Jurnal Ilmiah Vastuwidya*, 3(2), 23-31.
- [17]. Rosyidie, A., Sagala, S., Syahbid, M. M., & Sasongko, M. A. (2018). The current observation and challenges of tourism development in Batur Global Geopark area, Bali Province, Indonesia. In *IOP Conference Series: Earth and Environmental Science* (Vol. 158, No. 1, p. 012033). IOP Publishing.
- [18]. Saaty, T. L. (1989). Group decision making and the AHP. In *The analytic hierarchy process* (pp. 59-67). Springer, Berlin, Heidelberg.
- [19]. Sen., et al. (1998) *Multiple Criteria Decision Support in Engineering Design*. Springer-Verlag, London.

- [20]. Sugiarta, I. M. D. E., & Suharta, N. (2018). Legalitas Penambangan Material Galian C di Kawasan Geopark Batur, Kecamatan Kintamani, Kabupaten Bangli. *Kertha Negara: Journal Ilmu Hukum*.
- [21]. Suryadi, K. dan Ramdani, A. (2002) Sistem Pendukung Keputusan: Suatu Wacana Struktural Idealisasi dan Implementasi Konsep Pengambilan Keputusan PT. Remaja Rosdakarya, Bandung.
- [22]. Wendita, S. A. T. (2019). Pengembangan Geowisata dan Perubahan Sosial-Budaya Masyarakat di Area Geopark Ciletuh-Palabuhanratu. *Umbara*, 4(1), 31-43.
- [23]. Wiguna, I. K. A., Budiarta, I. G., & Citra, I. P. A. (2017). Dampak Aktivitas Penambangan Pasir dan Batu terhadap Kelestarian Geopark di Kaldera Gunung Batur, Kecamatan Kintamani, Kabupaten Bangli. *Jurnal Pendidikan Geografi Undiksha*, 5(3).
- [24]. Wu, P., Zhao, G., & Li, Y. (2022). Green Mining Strategy Selection via an Integrated SWOT-PEST Analysis and Fuzzy AHP-MARCOS Approach. *Sustainability*, 14(13), 7577.
- [25]. Yandra, A. (2016). Partisipasi Masyarakat dalam Penyusunan Rencana Pembangunan Jangka Menengah Daerah (RPJMD) Kota Pekanbaru 2012-2017. *PUBLIKA: Jurnal Ilmu Administrasi Publik*, 2(1), 48-58.