SUSTAINABILITY ANALYSIS OF LIMESTONE INDUSTRIAL AREA BUKIT TUI KOTA PADANGPANJANG

Titi Syafura[1], Dedi Hermon[2]

[1.] Master of Geography Education Study Program, Faculty of Social Sciences, Padang State University
[2.]Lecturer of Master of Geography Education Study Program, Faculty of Social Sciences, Padang State University
Email : syafuratiti@gmail.com

ABSTRACT : This study aims toanalyze the sustainability of the Bukit Tui area of Padangpanjang City in a multidimensional manner based on ecological, economic, social, institutional and technological dimensions. The data used are primary data, analyzed using *a multidimensional scaling* (MDS) analysis approach, developed into the *Rapfish* (*Rapid Appraisal of Fisheries*) application, *Leverage* analysis and *Monte Carlo* analysis and secondary data obtained from the results of field conservation and literature review and related agencies. This research consists of 38 attributes from five dimensions, namely ecological, economic, social, technological and institutional dimensions. The results showed: based on *calculations using the multidimensional scalling* method, it was formulated that the sustainability status of the Bukit Tui area was *multidimensionally* in the fairly sustainable category with a value of 50.60 on a sustainability scale of 0-100, with a stress value of 0.132 and R^2 0.95. Each dimension has a fairly sustainable sustainability value with a range of values between 41.68 to 54.21. The ecological dimension has the lowest sustainability value, which is 41.68 is included in the less sustainable category and the institutional dimension has the highest sustainability value, which is 54, 21 is included in the moderately sustainable category, then followed by the technological dimension 41.98 is included in the less sustainable category, the social dimension is 52.10 and the economic dimension is 52.83 is included in the moderately sustainable category.

Keywords: *Bukit Tui, Sustainability, Multidimensional scalling (MDS)*

INTRODUCTION

Padang panjang City is a small city that has limited natural resources. The undulating natural topography adds to the factor of the smaller availability of effective land areas to be utilized. Bukit Tuiis a natural area in the form of limestone that can be used in Padangpanjang City. The Bukit Tui area and its surroundings are used as community residential areas, agriculture and plantations, as well as lime mining industry activities (Agreni, 2005). Most of the residents' livelihoods are lime miners who have been for years, with the beginning of traditional processing and now there are many factories with modern tools (Prabowo et al., 2020).Industrial activities can have a negative impact on life (Hartanto &; Fevria, 2017) Based on Putra &; HAR's observations, 2020 found several technical and economic problems in Bukit Tui limestone

mining, namely limestone miners in Bukit Tui tend to ignore important aspects of good and correct mining, such as work safety, environmental sustainability and value improvement. Utilization the activities of the limestone mining area and limestone industry in Bukit Tui have the opposite impact on the sustainability of Bukit Tui's function as a Protected Area.

Activities carried out in the Bukit Tui area in addition to community settlements, including limestone industry activities, agriculture, plantations, if all these activities take place simultaneously in the Bukit Tui area, it will affect each other and even change the function of life and environmental ecosystems of the Bukit Tui area as a protected forest area. In addition, limestone miners in Bukit Tui tend to ignore important aspects regarding good and

correct mining, broadly speaking, regarding good and correct mining such as work safety, environmental sustainability and increasing the economic value of these mining activities (Putra &; HAR, 2020)

According to Law No. 32 of 2009 article 1 states that the environment is the unity of space with all objects, forces, conditions and living things, including humans and their behavior that affect nature itself both the continuity of life and the welfare of humans and other living things. It can be interpreted that various problems arising in the environmental and social dimensions are basically inseparable from the activities carried out by humans in meeting their needs through the economic system.

If the problem is not controlled properly, it will have an impact on decreasing the carrying capacity of the environment and sustainable livelihoods for the people in the region. Sustainable development is a development approach that does not conflict between the goals and objectives in economic development policy and policies in environmental management that meet the needs of the present without sacrificing the needs of future generations, that is, economic growth that continues to be generated and increasing will not mean anything if the environmental degradation caused is not taken into account (Susanto et al., 2012)

Therefore, research on the sustainability of the Bukit Tui area is a strategic need to maintain the preservation of the function of the Bukit Tui area, related to this, it is necessary to do it by reviewing the management of the Bukit Tui area which is oriented towards sustainable analysis.

RESEARCH METHODS
Data Collection
Primary Data Retrieval
Primary data collection is carried out through surveys of respondents with interviews and filling out questionnaires. Respondents are communities, workers and *stockholders* related to mining and lime industry in Bukit Tui Area, Padangpanjang City. The collection was carried out directly in the field, through observation, filling out questionnaires and direct discussions with respondents.

Secondary Data Retrieval
Secondary data collection was carried out at the research location, such as the Padangpanjang City Environmental Office, Padangpanjang City SME Cooperative Trade Office, Padangpanjang City BPBD Office, Padangpanjang City Research and Development BAPPEDA Office, Padangpanjang City Subdistrict Office and Koto Panjang City Subdistrict as well as communities directly involved with mining activities and the Bukit Tui lime industry in Padangpanjang City.

The determination of respondents or research subjects based on the problems to be studied in the Bukit Tui area of Padangpanjang City is determined by Purposive sampling, meaning that one way to get research subjects is to select samples among the population according to what the researcher wants with certain considerations, namely the desired conditions and the existence of good communication skills under study.

Research Procedure
This study uses the ordination analysis method of RAPCOAL (Rapid Appraisal for *Coal Post-Mining*) which is a modification program of *RAPFISH (Rapd Appraisal for fisheries),* through the multi-dimensional scaling (MDS) method to assess the health and sustainability status of the management of the Bukit Tui mining area and limestone industry.

Rapfish is a software based on modified applications *of Microsoft Excel.* Based on the method, *Rapfish* is a method of rapid assessment of the sustainability status of an object based on a number of attributes, a multi-criteria decision-making method based on a multi-dimensional scale, attributes can be redefined or replaced according to available information, and uses ordination methods to determine sustainability status (Fauzi and Anna 2005). *Stages of Rapfish* analysis as referring to the operational guidelines of *Rapfish*eries The stages of analysis include steps (Pratama, Rahman Aulia, 2020)

a. Evaluate and determine the attributes of the three dimensions of sustainability of Mandeh Tourism Area (ecological, economic, and social) (*Attribute Review*)
b. Provides an assessment of each attribute that has been arranged from each dimension on an ordinal scale of 0 - 2 or 0 - 3.
c. Calculate index values and assess sustainability status
d. Determine leverage *factor*)
e. *Goodness of fit* assessment to determine dimensional accuracy and dimension assessment
f. *Monte Carlo* analysis to determine the effect of *random error* rates on models generated from *Multi-Dimensional Scalling* (MDS) analysis. For more details, the following is the framework of the stages of *Rapfish* operational guidelines:
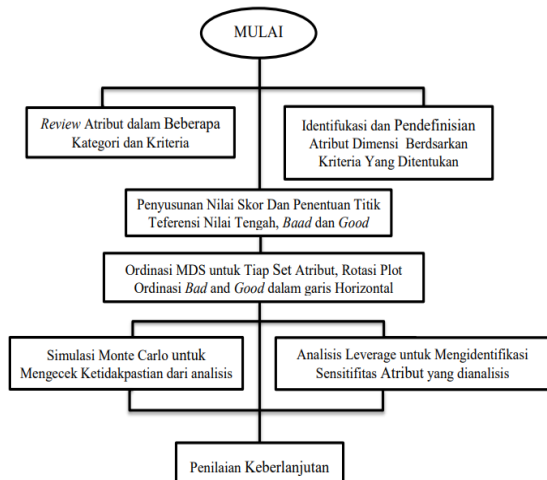
Figure *2* 2. Stages of Rapfish Analysis (Primary, Rahman Aulia, 2020)

All data from the attributes considered in the study were then analyzed multidimensionally to determine points that reflect the sustainability position of Bukit Tui mining area and mining industry management in each area studied relaitf to two reference points, namely good *andbad*. The position of sustainability points in this study is visually quite a lot, therefore to facilitate ordination analysis with the MDS method (Nurmalina, 2008)

Through the MDS method, the position of sustainability points can be visualized through horizontal and vertical axes, then the position of the sustainability index can be rotated on the horizontal axis. The sustainability index is the value of each dimension that describes the level of sustainability (Table 2.1). The sustainability index value of each dimension can be visualized at the same time in the form of a kite diagram, the condition and shape of the diagram are determined by the sustainability index of each dimension. Sensitive attribute analysis has the advantage of knowing the attributes that contribute to the sustainability value of resources and the environment, in addition to being used to see the output attributes of MDS analysis. The influence of each attribute is seen in the form of changes in the *rootmean square* (RMS), especially on the x-axis for sustainability scales (Kavanagh and Pitcher, 2004; Nurmalina, 2008; Suksika *et al*, 2018).

Table 2 1. Assessment Categories For Index Analysis and Sustainability Status

Skala Indeks	Kategori Status	Keterangan
00,00 - 25,00	buruk	tidak berkelanjutan
25,01 - 50,00	kurang	kurang berkelanjutan
50,01 - 75,00	cukup	cukup berkelanjutan
75,01 - 100,00	baik	berkelanjutan

Source : Fauzi &; Anna (2005); Nurmalina (2008); Prasodjo *et al* (2015); Sukwika (2018)

RESULTS AND DISCUSSION

Bukit Tui is a limestone hill or *limestone* hill that is lined in the south of Padang Panjang City. It is located between Rao-Rao Village to Tanah Hitam. Bukit Tui area with a local mining area (APL) of ± 329 Ha and limestone resources of 6,144,663,609 tons (ρ = 2.4 tons / m 3))) (A &; Nelvi, 2021). The slope of the Bukit Tui area of Koto Panjang sub-district consists of 0 to > 70% with soil types, namely Andasol with sandy clay and red yellow podosolic with sandy clay texture. Figure 3.1. describing that the Bukit Tui area is in an undulating hilly area, it can be interpreted that most of the Bukit Tui area of Koto Panjang village is at a medium danger level, with an area of 17.64 Ha with a moderate landslide hazard area of 86.77% of the total area of Bukit Tui.
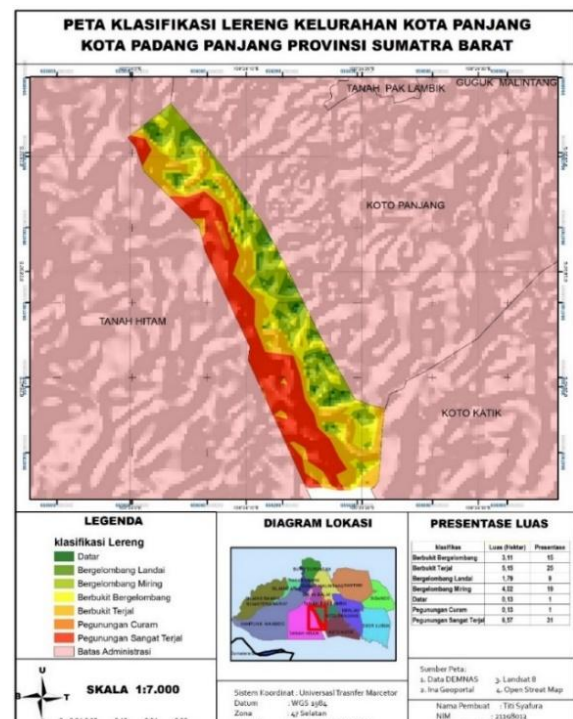

Figure 3 1. Map of Koto Panjang Village Area, East Padangpanjang District.

The problems that occur in the mining and lime industry in the Bukit Tui area based on the observations of researchers in 2023 are: 1) Many kilns have gone out of business, 2) minimal wages (2000-3000 / sack), 3) the quality of limestone is not as good as in previous years, 4) limestone fuel is low and difficult to obtain, 5) limestone production areas are increasingly difficult, 5) There is no guarantee of work safety, 6) the tools used tend to be traditional.

Sustainability of Bukit Tui Mining and Limestone Industry Area

Sustainable development does start from the main problem of how to manage natural resources effectively and efficiently, so that they can meet the needs of humans today without sacrificing the ability of future generations to meet their needs. Poor management of natural resources can result in environmental damage, decreased quality of life, and disruption of ecosystem balance, which in turn can worsen sustainability conditions. In the aspect of the Bukit Tui area, sustainable is intended to manage limestone mining wisely and responsibly so as to minimize negative impacts on the environment and local communities, as well as maximize economic and social benefits for the community and related parties.

The sustainability index of Bukit Tui area management is analyzed through *Rap-CArea* and sustainability status based on predetermined categories. Statistical parameters in this study consisted of *monte carlo* analysis, *stress* value and R^2. The results of the analysis show that the *stress* value obtained in each dimension and multidimension has a value smaller than the provision (<0.25), which is smaller than 0.25 the better and for the value of the coefficient of determination (R^2) in each dimension and multidimensional, all values are close to 1, so that from these two statistical diameters it explains that all attributes used and analyzed dimensionally and multidimensionally have met the criteria statistics and worthy of explaining the sustainability of the Bukit Tui Area of Padangpanjang City.

Table 3 1. Statistical parameters (*goodness of fit*) from the index analysis and sustainability status of Bukit Tui Area.
Source : Primary Data Processing, 2023

Based on Table 3.1 shows that the *stress* value is in the range of 0.13-0.15 and the average R2 value is in the value of 0.93-0.95, which means that the *goodness of fit value in* this analysis has been met. The value of R^2 describes that the strength of the attribute in explaining and contributing to the continuity of the system under study can be met. The *stress* value is sufficient, then the attribute configuration is able to explain the original data so that it can be stated that the indicators studied are sufficient, accurate and statistically accountable. *Monte Carlo* analysis is used to evaluate the effect of errors whose main purpose is to find out: a) the effect of errors in making attribute scores, b) the effect of variations in scoring scores, c) the stability of the repeated MDS analysis process, d) entry *errors* and *missing data* and e) *acceptable stress* values if less

Description	MDS	Monte Carlo	Difference	Stress	R^2
Multidimensional	50,60	50,36	0,24	0,132	0,956
Ecology	41,68	41,52	0,16	0,152	0,943
Economics	52,83	52,62	0,21	0,159	0,939
Social	52,10	51,82	0,28	0,149	0,944
Institutional	54,21	53,94	0,27	0,159	0,938
Technology	41,98	41,92	0,06	0,157	0,937

than 25%. Monte *Carlo* analysis in this study shows that the sustainability index value of the Bukit Tui area of Padangpanjang City at a 95% confidence level can be seen from the results of *the Rap analysis analysis*, including MDS and *monte carlo*, there is no significant difference.

Sustainability of Bukit Tui Mining and Limestone Industry Area Based on Dimensions

The results of the analysis of the sustainability index value of the management dimension of the Bukit Tui Area of Padangpanjang City consist of 5 (five) dimensions. The sustainability index value of each dimension includes the ecological dimension (41.68) less sustainable, the economic dimension (52.83) quite sustainable, the social dimension (52.10) quite sustainable, the institutional dimension (54.21) quite sustainable and the technological dimension (41.98) less sustainable (Figure 3.2 &; Figure 3.3)
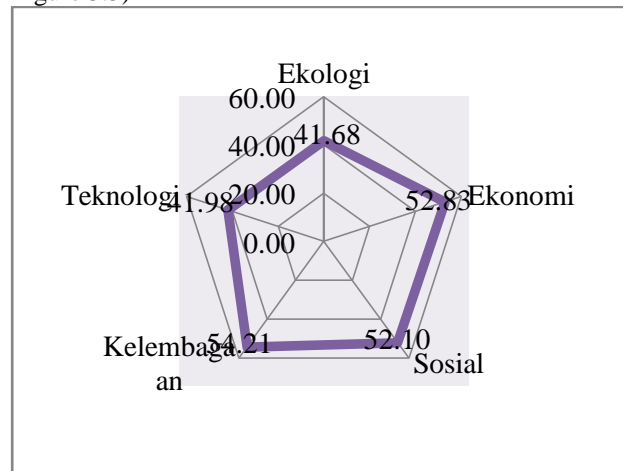

Figure 3 2. Kite Diagram of Bukit Tui Area Management Continuation Index of Padangpanjang City

The projection of the sustainability dimension value on the kite diagram can be interpreted as a visualization of how sustainable the management of the Bukit Tui Area of Padangpanjang City is based on the points given by each sustainability dimension, where if the sustainability point leads out of the midpoint, the sustainability value is even greater.

Figure 3.2 shows that the ecological dimension has the lowest sustainability value of the other four dimensions, while the highest is the value of the institutional dimension. The following is a visualization of the sustainability index and analysis of *leverage of attributesof* Bukit Tui area management based on each dimension (Figure 3.3)

The results of the sustainability analysis of Bukit Tui Area management on the ecological dimension can be seen from the *Rap Ordination* value is 41.68 on a sustainability index scale of >25-50 with a less sustainable category. The *stress* value is 0.152 (<0.25) and the determination coefficient value (R^2) is 0.94 (closer to 1). The meaning of unsustainable management of Bukit Tui Area and its surroundings is environmental damage or degradation, especially related to its natural ecosystem. Limestone mining can cause disruption of natural ecosystem functions. In contrast to the results of *the Rap Analysis* analysis with a focus on the economic dimension, a sustainability index value of 52.83 was obtained indicating a sufficient category of sustainability. Furthermore, a stress value of 0.158 (<0.25) is considered relatively stable and sustainable with a *coefficientvalue of determination* (R^2) of 0.94 indicating *a* high level of explanation. The meaning is quite sustainable, namely the industrial area and limestone mining The Bukit Tui area provides significant economic contribution, as evidenced by the workers in the mining area and limestone industry are the people who live around the Bukit Tui area.
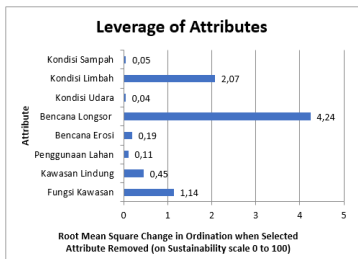
While the results of the *Rap Ordination* analysis on the social dimension, the Bukit Tui area of Padangpanjang City has a fairly sustainable sustainability status, an index value of 52.10. It is on a sustainability index scale of >50-75. The results of the analysis also showed statistical parameters that supported the validity of the analysis, with a stress value of 0.149 (<0.25) and *a coefficient* of determination (R^2) of 0.94 (close to 1). The meaning of being quite sustainable in this context still remains relevant. Where there are still aspects of sustainability as a whole has not been done by the community around the Bukit Tui area. When viewed from the side, the institutional dimension of 54.21 is included in the category of quite sustainable, with a sustainability index scale between >50-75. Institutions do have an important role in sustainable management. The existence of good institutions can reduce transaction costs between stakeholders, reduce conflicts, and facilitate the implementation of more efficient technology. With strong institutions, decision making can be carried out in a coordinated and collaborative manner, thus enabling the implementation of a more sustainable management program.
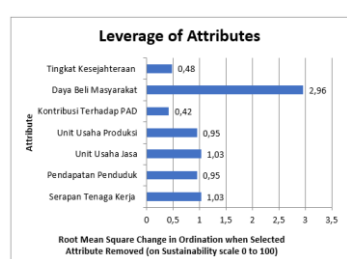
No less important, the results of MDS analysis using *Rapfish* analysis *software* from the technological dimension obtained a sustainability index value of the Bukit Tui area of Padangpanjang City of 41.98. These results show that the sustainability status of the Bukit Tui area is in the less sustainable category. This is in accordance with the opinion (Halim, 2013) that the index value of >25-50 is categorized as less sustainable. This shows that the technology used is not adequate for the sustainability of the region. obtained *a stress* value of 0.157 and an $R^{value of 2}$ of 0.93. This result shows that the model of the sustainability technology dimension of the Bukit Tui area of Padangpanjang City has used good attributes.
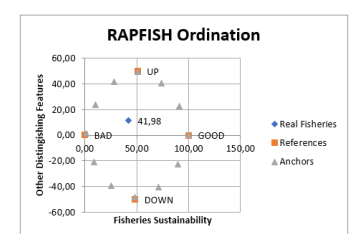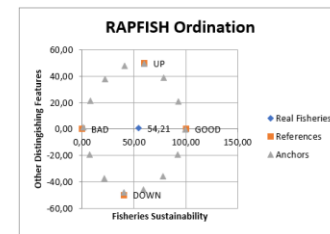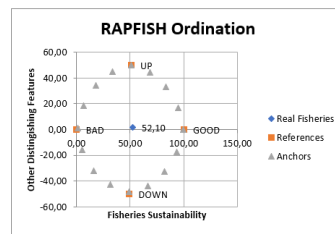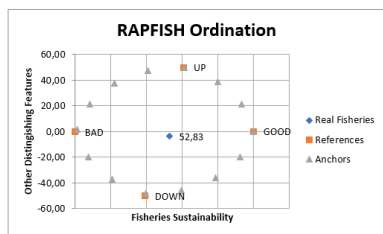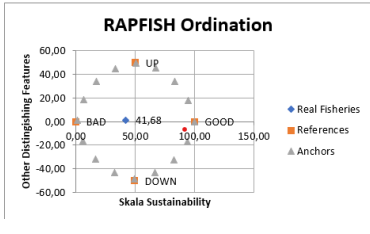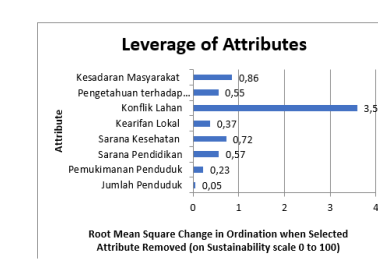
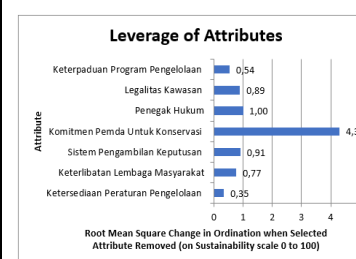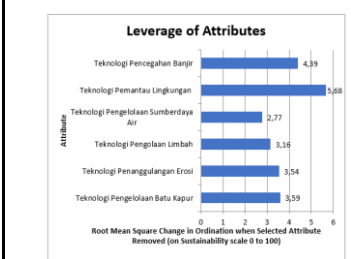|				
Management Sustainability Index Bukit Tui Area Ecological Dimensions	Management Sustainability Index Bukit TuiArea Economic Dimension	Management Sustainability Index Bukit TuiArea Social Dimension	Management Sustainability Index Bukit TuiArea Institutional Dimension	Management Sustainability Index Bukit TuiArea Technology Dimensions

Analysis of Leverage of attributees ecological dimensions	*Analysis of Leverage of attributees* Economic dimensions	*Analysis of Leverage of atributes* Social dimension	*Analysis of Leverage of atributes of* Institutional dimensions	*Analysis of Leverage of Atributes* Technology dimensions

Figure 3 3. Sustainability Index and *Analysis of Leverage Of Atributes* Management of Bukit Tui Area Based on Dimensio

Multidimensional Sustainability Index and Status

The results of *rapfish* analysis using the *multidimensional scalling* method obtained a sustainability index value of Bukit Tui Area, Padangpanjang City of 50.60 on a sustainability scale of 0-100, which is in the fairly sustainable category with *a stress* value of 0.132 and R^2 0.95. The analysis is a combination of all dimensions (ecological, economic, social, institutional and technological) which is then called multidimensional. Each dimension has attributes that become a benchmark for the sustainability of the Bukit Tui Area of Padangpanjang City. In the context of regional sustainability, *leverage* analysis can be used to identify the most sustainability-sensitive attributes within a dimension (Table 3.2). The RMS value is the result of calculating the distance between the expected and actual numbers where the value is between 1-6 (Fauzi, 2019).

Table 3 2. Results of Levarge Analysis in the Bukit Tui area of Padangpanjang City

Dimensi	Atribut sensitive	Nilai RMS
Ecology	1. Landskide disaster	4,24
	2. Waste conditions	2,07
	3. Regional functions	1,14
Economics	1. People's purchasing power	2,96
	2. Labor absorption	1,03
	3. Service business units	1,03
Social	1. Land conflicts	3,59
Institutional	1. Local government's commitment to conservation	4,31
	2. Law enfoecement	1,00
Technology	1. Enviromental monitoring technology	5,68
	2. Flood prevention technology	4,39
	3. Limestone management technology	3,59
	4. Erosion control technology	3,54

From the distance analysis through RMS numbers, it can be seen that the greater the RMS value, the greater the influence of these attributes on sustainability. Obtained 1 to 4 attributes that most sensitively affect sustainability in each dimension. For the ecological dimension, which has the smallest sustainability index value among other dimensions, there are several key attributes that can be considered to improve sustainability.

CONCLUSION

The *multidimensional scalling* approach is a statistical technique that tries to transform multidimensionally into lower dimensions, with the aim of seeing the condition of the sustainability status of each dimension. The results of using the multidimensional *scalling* method in the sustainability status of the Bukit Tui area in a *multidimensional* manner are in the fairly sustainable category with a value of 50.60 on a sustainability scale of 0-100, with a stress value of 0.132 and R^2 0.95. Each dimension has a fairly sustainable sustainability value with a range of values between 41.68 to 54.21. The ecological dimension has the lowest sustainability value, which is 41.68 is included in the less sustainable category and the institutional dimension has the highest sustainability value, which is 54, 21 is included in the moderately sustainable category, then followed by the technological dimension 41.98 is included in the less sustainable category, the social dimension is 52.10 and the economic dimension is 52.83 is included in the moderately sustainable category

. BIBLIOGRAPHY

Agreni, E. (2005). *Critical study of the utilization assessment of the Bukit Tui Area of Padang Panjang City*. 2–4.

Fauzi, A and Anna, S. (2005). *Fisheries and marine resource modeling for policy analysis.* Jakarta. Gramedia Main Library.

Hartanto, I., &; Fevria, R. (2017). Impact of Bukit Tiu Limestone Mining on Air Quality in Padang Panjang City. *Tower of Science Journal*, *XI*(77), 50–56.

Marlina, A. N. (2021). Studi pemetaan kualitas batu gamping bukit tui kota padang panjang menggunakan XRF dan XRD untuk memenuhi requirement industri Kawasan Bukit Tui Kota

Padang Panjang berada sebelah utara Bukit Jarat dengan luas pemasaran yang pasti dan produk yang dipasark. *Jurnal SAINS DAN TEKNOLOGI KEILMUAN DAN APLIKASI TEKNOLOGI INDUSTRI*, *21*(September), 146–155.

Nurmalina, R. (2008). Keberlanjutan sistem ketersediaan beras nasional : pendekatan teknik ordinasi rap rice "Jurnal Agribisnis dan Ekonomi Pertanian, 2(2), hal. 65-88.

Prabowo, H., Kopa, R., & Cerya, E. (2020). Managemen Ukm Industri Kapur Di Daerah Tambang Batukapur Bukit Tui, Kota Padang Panjang, Sumatera Barat. *Seminar Nasional ADPI Mengabdi Untuk Negeri*, *1*(1), 49–54. https://doi.org/10.47841/adpi.v1i1.23

Pratama, Rahman Aulia, I. (2020). Analisis Keberlanjutan Kawasan Wisata Mandeh Provinsi Sumatera Barat. *Jurnal Buana*, *4*(3), 486–502.

Putra, R. S., & HAR, R. (2020). Kajian Teknik Dan Nilai Ekonomi Pengolahan Batu Kapur Pada Pertambangan Batu Kapur Rakyat Bukit Tui, Padang Panjang, Sumatera Barat. *Jurnal Bina Tambang*, *5*(2), 99–112.

Sukwika, T., Darusman, D., Kusmana, C. dan Nurrochmat, D.R. (2018) Skenario kebijakan pengelolaan hutan rakyat berkelanjutan di kabupaten Bogor, *Jurnal Pengelolaan Sumberdaya Alam dan Lingkungan* (*Journal Of Natural Resources and Enviromental Managemnet)*, 8(2), hal. 207-215. doi : 10.29244/jpsl.8.2.207-215.

Susanto, A., Rusdiyanto, E., & Sumartono. (2012). *Analisis Keberlanjutan Pemanfaatan Situ Kedaung , Kecamatan Pamulang Kota Tanggerang Selatan*.