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Rapfish analysis on sustainability status of post-tin mining in Jebus subdistrict, West Bangka Regency, Bangka Belitung Islands Province, Indonesia

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ABSTRACT

Bangka is well known as the largest tin producer in Indonesia that has widely ruined the environment due to exaggerated exploitation. The extreme exploitation potentially generates landscape changes that are caused by the formation of giant pools with tailings and overburden. The aim of this research will analyze the sustainability of post-tin mining conducted in Jebus Regency, West Bangka Regency, Bangka Belitung Islands Province. The data are obtained by filling questionnaires which is assessed in three aspects such as environmental, economic, and social. These aspects contribute to the post-tin mining sustainability and arranged through observations, literature reviews, and previous studies. This study involved 166 respondents who were randomly selected in 11 villages in Jebus sub-district, West Bangka Regency. The results show that the post-mining sustainability status in multidimensional is less sustainable. The environmental and economic dimensions are less sustainable while the social dimension is sustainable. Sustainable or less sustainable status depend on the five greatest attributes of leverage sustainability status of tin mining in the environmental, economic, and social dimensions

Key words : Sustainability Status, Post-tin Mining, Jebus Sub district.

Introduction

Bangka island has the most extensive tin producer in Indonesia with the total area around 1.29405 million ha. Tin mining authorizes a part of the total area around 27.56% such as PT. Tambang Timah (a subsidiary of PT. Timah Tbk) handles 321.577 ha and PT. Koba control 35.063 ha (PT. Timah, 2018). Besides these companies, tin mining authorization is also granted to private companies. There are other

parties and traditional miners namely, unconventional mining (UM) spreading on the mainland and coastal area of Bangka Belitung province.

The problem of tin mining emerged when the number of UM increase in every year. Mining activities have contributed to the economic and social aspects of the community in the mining area both positively and negatively. Positive contributions check on the enhancement incomes, employments, migrations and population growths, and social fa-

cilities. Furthermore, tin-mining also contributes the negative impacts to the land degradation, the crime rates, loss of the agricultural land and cultural heritages, the flood in 1) tions (Yuliana, 2017).

Previous study about the impact of mining activities on the environment, economy and social community have been undertaken by Juniah (2017a), Global Report Initiative (2013), Mulyana and Djajadiningrat (2013), Batterhama (2014), Pradsojo (2015), Morrison-Saunders *et al.* (2016), Kodir *et al.* (2017), Que *et al.* (2018), Virgone *et al.* (2018) as guidance to assess the problem of implementing post-tin mining management in sustainable way in Bangka island.

The purpose of this study is to analyze the sustainability status of tin mining on three environmental, economic and social aspects as a result of the positive and negative impacts caused by mining. An analysis of the sustainability status of tin mining was carried out using the Multidimensional Scaling (MDS) approach, where environmental, economic and social aspects will be calculated using the Rapsfish method. The results of the sustainability status analysis are expected to provide input on post-mining environmental management policies in Jebus District, West Bangka Regency, Bangka Belitung Islands Province. The paper is organized as follows. Materials and methods describe about the

data and method used in the present study. Results and Discussions present a general description of sustainable status in environmental, economic, and social dimensions. The summary is presented in conclusion.

Materials and Methods

The research was located at Jebus Subdistrict, West Bangka Regency, Bangka Belitung Islands Province (Figure 1). The area was selected due to the most tin production in West Bangka Regency comes from tin mining in Jebus District (Central Bureau of Statistics in West Bangka district, 2019). Furthermore, the studied area was mostly under the authority of PT. Timah Tbk as the main tin mining company (PT Timah Tbk, 2018a; 2018b). The research was conducted from January 2019 to June 2019.

Population and research sample: The sustainability status consists of three multidimensional for analyzing the sustainable environment. Those are involving environmental, economic, and social factors which was evaluated based on determine with the MDS method (Borg *et al.*, 2013; 2018; Ding, 2018; Juniah, 2017b; Lidster, 2018). The population is the village community in Jebus District, while the study sample is the community that is af-

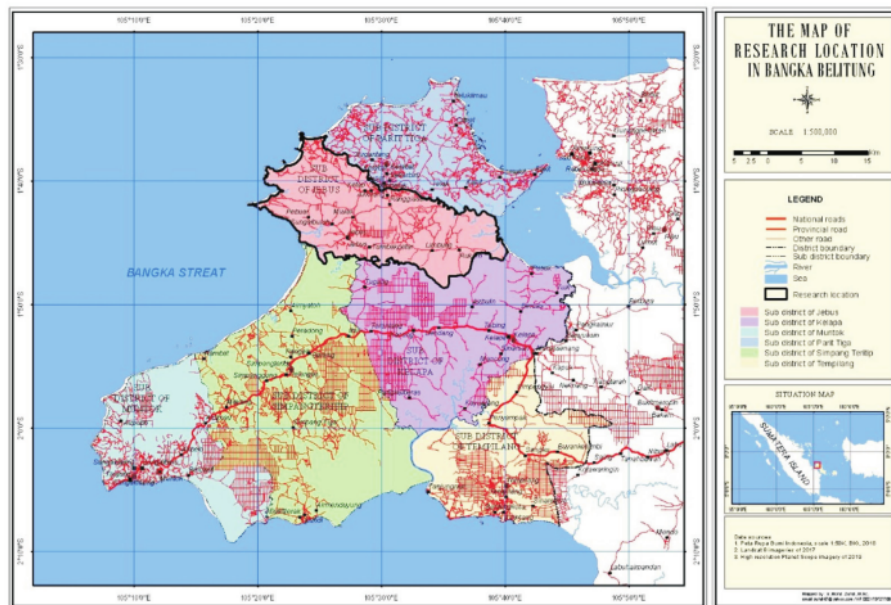


Fig. 1. The location of study area

ected by tin mining activities. To be more specific, the selected population is the community from 11 villages around tin mining area in Jebus sub-district such as the village of Jebus, Mislak, Pebuar, Rangi Asam, Sungai Buluh, Tumbak Petar, Sinar Manik, Water Kuang, Limbung, Ketap, and Rukam. There were 15 respondents selected as the actors or parties involved in the tin mining activities from each village. The sample would answer the questionnaire and the sample is selected using the purposive sampling method. The selection of the sample is determined by the researcher based on the research objectives with certain criteria. The main consideration for choosing this method was because of the heterogeneous sample with different social and economic backgrounds, thus we thought that the result of this study does not aim to generalize, and limitations on researchers (Creswell, 2014). Several criteria such as having knowledge related to tin mining management, being willing and willing to participate, and being able to communicate their experiences in clearly and effectively were set to select the sample. In this study, the number of samples was 65 people from 11 villages, of which this number represented each village adjacent to tin mining activities.

Data collecting method : Data was collected by formulating the questionnaire results (environmental, economic, and social dimensions) which was calculated by statistical software. MDS method developed for mining (Rap-TinMining) to find out the index continuity (Pitcher and Preikseho, 2001 and Pitcher *et al.*, 2013). The formulation of the concept of sustainability status is followed by the formulation of the attributes of each dimension and gives an ordinal score on these attributes. The attributes used in assessing the tin mining sustainability index are 32 attributes consisting of 12 attributes of the environmental dimension, 10 attributes of the economic dimension, and 10 attributes of the social dimension. The next data collection was done by using questionnaire data collection techniques that contained statements of the attributes of each of the

Table 1. The Sustainability Status of Tin Mining Activities

Index value (%)	Category	Result
0.00 – 25.00	Worse	Unsustainable
25.01 – 50.00	Less	Less sustainable
50.01 – 75.00	Sufficiet	Quite Sustainable
75.01 – 100.00	Good	Very sustainable

Sumber: Pitcher *et al.*, 2013

sustainability dimensions that had been scored in the order of bad to good categories.

The questionnaire was answered by the respondent that was processed by using the MDS Rapfish software. The data using this approach produces; 1) the sustainability index of the post-tin mining post points out its sustainability status; 2) the scores of root mean square (RMS) or the most sensitive attribute gives contribution to the sustainability status of post-mining activities. Furthermore, each dimension was taken from the 5 largest indices to be used in the post-tin sustainability analysis. Next, each attribute resulted in 15 attributes that are obtained for further analysis.

Data Analysis Method : The data analysis are carried out by giving interpretations to: (1) the assessment of the sustainability status of each attribute in ordinal scale. The assessment results indicate the sustainability status of each dimension which is stated to be worse (unsustainable), less (less sustainable), sufficient (quite sustainable), and good (very sustainable) and arranged by its rank; 2) Leverage sensitivity attributes on root mean square (RMS) values based on the highest attributes to improve the sustainability status of post-tin mining; and 3) the multidimensional sustainability status of the environmental, economic, and social dimensions. These multidimensional sustainability status determines the final sustainability status of tin mining in Jebus District. These sustainability status is visualized by kite diagram to point out the diversity of the sustainability status of each dimension.

Data Validation : MDS analysis results are conducted by determining the stress value and the coefficient of determination (R2) (Borg *et al.*, 2013; 2018; Ding, 2018). The analysis results are characterized to be quite adequate if the stress value is less than 25% (< 0.25) and R2 values are close to 1 (< 1). The stress and R2 reveal that sustainability assessment is accurate and can be accounted for considering the level of error in the attribute assessment procedures, the score differences, the MDS sustainability status, and the input or missing data errors (Borg *et al.*, 2013; 2018; Ding, 2018).

Results and Discussion

Multidimensional analysis. The leverage sustainability status of tin mining activities in Jebus district pointed out Table 2. These results have less

sustainable in general that can be used for further consideration in managing the tin mining environment. Figure 2 and Table 2 indicated 44,39% of the multidimensional value with less sustainable status. The partial dimension has the highest continuous index is the social dimension (54.74%) followed by the environmental dimension (44,45%), and the economic dimension (33,97%). However, economic and environmental dimension is considered as the highest priority dimension that must be fulfilled as quite sustainable in realizing the sustainable management of the tin mining activities.

According to Sufrianto (2019), the management of post-coal mining area in Banjar showed less sustainable with 47.66% multidimensional sustainability index. Each score of three sustainability dimensions shows that environmental dimension is 49.17%, economic dimension is 44.29%, and social dimension is 47,48% with 10 lever factors which can be intervened towards improvement. A similar study was also conducted by Prasodjo (2015) who was studying the sustainability status by using MDS method. The result showed that the mining activity in Samarinda a was classified as less sustainable with a 47.57% multidimensional index score. The sustainability score consisted of the economic dimension is 49,86%, the social di-

mension is 47.29%, and the environmental dimension is 45.35%. The natural resource management of Banjar case must be improved to be more sustainable including monitoring and controlling the impact of mining activities on the environment (air, land and water), and in particular understanding and managing sustainability sensitive factors as an integrated part in the implementation of development management policies in Samarinda City.

The results of the Monte Carlo analysis in this study at a 95% confidence level showed that there was no significant difference between the RTM results and the Monte Carlo tests. These results were indicated by a small difference in value (0.51%). The errors of these results were relatively small in each attribute. The score differences were relatively small and the data analysis was carried out repeatedly stable, so data errors can be avoided. The difference in the the sustainability index with MDS and Monte Carlo analysis can be seen in Table 3. The result between the RTM results and the Monte Carlo tests indicated a small difference value with the differences as 0.55%, 0.25%, and 0.76%, respectively.

Environmental Dimension: The results of the analysis on the environmental dimensions show the most sensitive lever attribute influences in improving and increasing the sustainability index of the environ-

Table 2. The Five Greatest Attributes of Leverage Sustainability Status of Tin Mining in the Environmental, Economic and Social Dimensions.

	Dimension	RMS
	Environmental	Value
1.	Water pollution	8.81
2.	Soil pollution	7.67
3.	The land conservation and structuring program of the disrupted area	7.09
4.	Disturbance level of mining activities	6.70
5.	Water availability and quality	5.34
	Economical	
1.	Mining sector contribution to gross regional domestic product	6.49
2.	Mining sector contribution to local society income	6.09
3.	Economic sector after mining activities	6.01
4.	The existence of economic facilities	5.61
5.	The economic value of ex-mining land	5.52
	Social	
1.	The relationship between local society around mining facilities and mining industry players	8.81
2.	Community empowerment in tin mining activities	6.80
3.	Conflict frequency	6.05
4.	Mining and post-mining effects on the socio-cultural values changes	5.70
5.	Mining activities effects on local education development	5.18

Table 3. The Sustainability Index of Post-Tin Mining Activities.

Dimension	Sustainability Index (%)		Differences (%)	Stress	R ²
	Multidimensional Scaling (MDS)	Monte Carlo			
Environmental	44.45	44.59	0.14	0.17	0.85
Economical	33.97	34.95	0.98	0.15	0.91
Social	54.74	54.32	0.42	0.18	0.82
Multi	44.39	44.62	0.51	0.17	0.86

mental dimensions of tin mining activities. Water pollution comes from liquid waste from the overflow that comes out of the settling pond, groundwater at the site of the former mining quarry. Both solid and liquid waste can be caused water pollution. In the tin mining process, water quality will be affected by the activities of stripping and landfill cover, tin mining in the mine area, drainage of mine water, landfill and tin processing. These findings are supported and reported that tin mining activities on Bangka island caused environmental damage due to the landscape changes such as tailings and overburden on the land. The availability and water quality in an ecosystem depend on the vegetation conditions, rainfall, soil, rock types and soil hydrological functions. Mining has a negative impact, especially unconventional tin mining on land damage and changes in river flow. These findings are also in accordance with some studies conducted by Bastida (2003), and Erthalia *et al.* (2018). The existence of mining activities on the land surface interferes the local ecosystem condition that can affect the surface water and groundwater scarcities in the dry season and flood in the rainy season. These conditions happened due to poor management of the water availabilities which related to the local ecosystem conditions in the area mining (Yuliana, 2017; Rahmi *et al.*, 2018; ZWU, 2019).

Soil morphological conditions affected to the land of post-mining activities (Laurence, 2011; Kretschmann *et al.*, 2017). Mining activities produce solid waste which can be sourced from stripping the top soil as a brown to yellowish sand. This condition can cause erosion on the surface of the soil, especially in the rainy season. The level of soil fertility and tailing on ex-tin mining areas were very low due to losing top soil, leaching and drifting nutrients. The severe impact of soil changes in physical, chemical, and biology resulted to land degradation (Jurairah, 2014). Mining activities also produced liquid impacts which effected the water pollution in the soil such as reducing pH and elevating the lev-

els of heavy metal contaminants (Ashraf *et al.*, 2012).

Land degradation and water pollution caused erosion which released rock from its exposed place taken by moving the rock through the air for subsequent deposition as sediment. These sedimentary events are a combination of the nature and mix of human hands such as rain, temperature, wind, soil factors and the level of difficulty of the soil carried out by humans in mining activities.

Analysis of the status of sustainability is carried out on the environmental dimension by using the Multidimensional Scaling (MDS) approach. This approach has been used by several previous studies related to assessing the level of sustainability of mining areas. Research analyzing the sustainability of coal mining shows that in Banjar City conducted by Sufrianto (2019) which resulted in findings that the environmental dimension is included in the unsustainable category. Impacts caused by mining activities contribute to the destruction of environmental ecosystems such as water pollution, erosion and flooding. The impact was caused by the loss of vegetation around the mining area.

Research on tin mining shows the same impact as coal mining. The distribution pattern of the tin mining sustainability status in the environmental dimension is shown in **Figure 2a**. the blue color represents the community around tin mining, the red color represents the boundary of the sustainability category, the gray color is the attribute of questions related to the environmental dimension (12 questions). While the direction of distribution below the left shows the number of environmental dimensions with the Rappfish software.

Rappfish research analysis results related to the sustainability status of the tin mining environment on the environmental dimension, obtained a sustainability index value of 44.25% which falls into the less sustainable category. This value indicates that the sustainability status of the environmental dimension requires special attention to be improved

and improved its sustainability index. The results of this analysis indicate the most sensitive lever attribute influences to be able to improve and improve the sustainability index of the environmental dimensions of tin mining activities, namely water pollution 8.81%, soil pollution 7.67%, then followed by conservation programs and structured disturbed land 7,09%, land disturbance rate 6.70%, also water availability and quality 5.34%. So that disturbance to land is closely related to water quality and soil fertility in mining areas is a priority in conservation programs to arrange disturbed land as a solution for environmental management.

The conservation and structured land arrangement program through conservation programs for the maintenance flora, fauna and hydrological conditions which are parts of the government program and the company's obligation to maintain and restore negative mining. These impacts can be re-

stored as before. Land capability is related to the type and nature of the soil and the land use plan. Soil conservation programs are carried out by understanding land suitability and land capability and evaluating current land conditions (Kodir *et al.*, 2017; Nurtjahya *et al.*, 2017 and Wildayana, 2014). Restoration of disturbed land with two choices, returned to the original function or become another function based on the agreement of the stakeholders. Forests cleared for mining purposes, after mining can be returned to forest again or become other land functions (Kivinen, 2017; Hendri *et al.*, 2018), such as: plantations and agriculture (Sitorus *et al.*, 2010; or recreation and tourism areas (Purnaweni *et al.*, 2019).

Economic Dimension. The rap-tin mining results of economic dimension show the sustainability distribution values towards the left which indicate bad or bad (33.97%) presented by Figure 2b. Those values

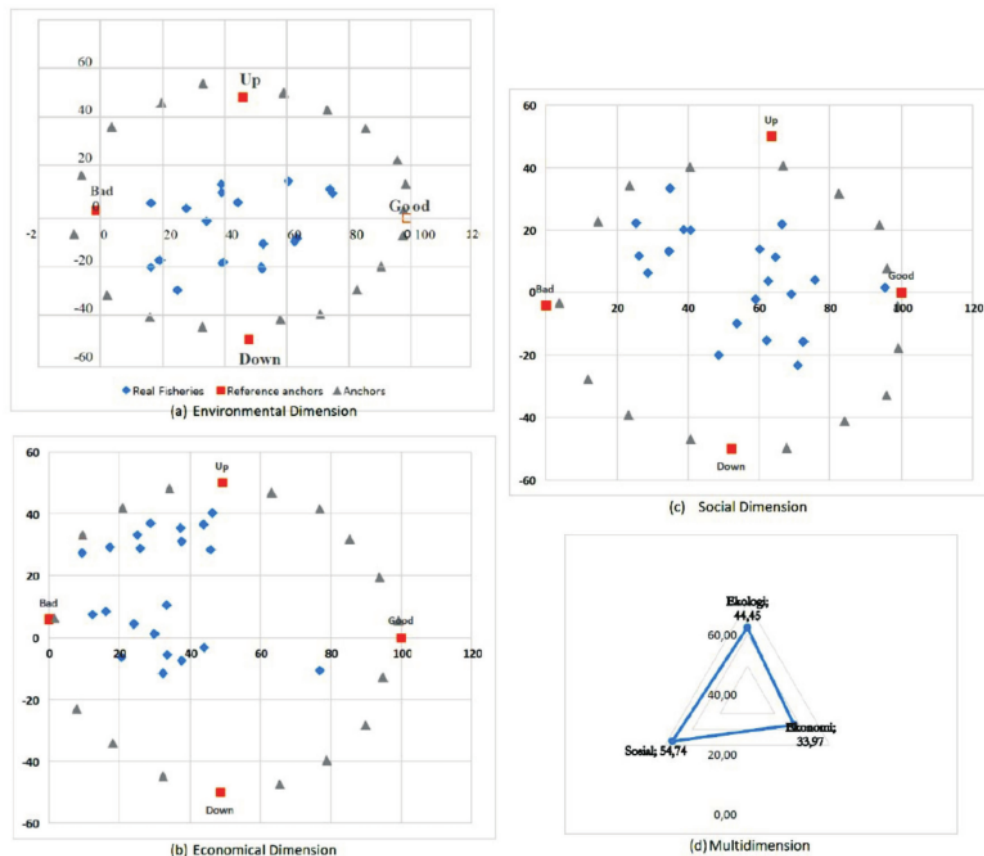


Fig. 2. The Result of MDS Rap-TinMining.

confirmed less sustainable status and the RMS Leverage Attributes value of economic dimensions revealed on Table 2. The RMS values on Table 2 can be used as references to improve economic sustainability index for tin mining activities, relating to the welfare of the affected communities around the tin mining area. The contribution of tin mining activities to regional income is considered to be the main attribute because contributes to development, such as the improvement of facilities and infrastructure in the region. Improvement in the infrastructure and construction field have been contributed to the development of the regional economy, especially the community economic developments. The results of this development can encourage the economic activity developments and increase community incomes.

Tin mining communities in Jebus sub-district have the variation of income sources starting from government employees, traders, and farmers. The community income is obtained from direct and indirect results from mining starting from the results of local workers who work in mining, community development activities of mining companies, local spending from the company on mining operations, both employee needs and mining operation needs. The sustainability dimension is the main part that needs attention after post-tin mining periods. The period 2003-2008 increased an increase of 199% (ring 1) and 132% (ring 2) from the period before 2003, then increased by 17% (ring 1) and 10% (ring 2) in the period 2009-2011. During mining (2003), most of the villages surrounding the mine increased in hierarchy, most of the ring 1 villages, but when mining activities ended or post-mining in 2008, most of the ring 1 villages were successfully moved to a hierarchy.

Direct contribution of mining is its contribution to *Gross Regional Domestic Product* (GRDP) both direct and indirect. Direct GRDP contributions of tax and non-tax contributions given directly by the company to the region. Whereas indirect impact of the double mining effects usually becomes greater than the direct contribution, such as the growth of the transportation industry, mining supporting industries, etc. Mining and quarrying are no longer a source of business fields that contribute greatly to economic growth in Jebus District. Tin production in Jebus sub-district is the highest sub-district of tin production in West Bangka Regency. In 2018 there were 5,387 tons or 76.34% of tin production in West

Bangka Regency (Central Bureau of Statistics in West Bangka Regency, 2019). This number has decreased from the previous year, and is expected to continue to decline every year. Dependence on tin mining must be anticipated immediately considering the economic reserves of tin ore on Bangka Island is expected to be exhausted in the next few years. This situation must be taken into consideration in developing economic and development policies that are no longer centered on the mining and quarrying industry but are building other business fields, such as tourism.

The results of the analysis of this study related to the sustainability status of the tin mining environment on the economic dimension, obtained a sustainability index value of 33.27% which falls into the less sustainable category. This value indicates that the sustainability status of the economic dimension also requires special attention to be improved its sustainability index. The most sensitive attribute influences to improve the sustainability index of the economic dimensions of tin mining activities, namely the direct contribution of mining to the GRDP 6.49%, the effect on community income 6.09%, post-mining economic activity 6.01% , the existence of economic facilities and infrastructure is 5.61%, and the economic value of ex-mining land is 5.52%. Attention to efforts to improve and enhance the status of economic sustainability is carried out by paying attention to priorities in increasing the economic activities of communities around the mine site such as increasing the economic value of ex-mining land through the conversion of land into fishing, plantation and tourism businesses.

The sustainability of the social dimension with status is quite sustainable which is shown in Fig. 2c and Table 3. The main concern which the expected sustainability status index should increase. The results of the analysis of the value of the RMS Leverage attributes of the social dimension sustainability in Table 2 are the most sensitive attributes that place the attributes of community relations with the mining industry in the position of the main lever attribute that should be a concern. The relationship between the community and the mining industry is still considered to be poor because there are still differences between company and community perceptions, especially regarding the post-mining reclamation and rehabilitation program. On the other hand, the company acknowledged that it had made maximum efforts to implement land reclamation and re-

habilitation programs. According to Erwana *et al.* (2015), many unlicensed mining (PETI) mined reclaimed land.

Many miners are migrants so that they have a different socio-cultural background than the local community. Miners have an economic motive to get benefit from their mining business, but efforts to establish harmonious relationships with communities around tin mining must also be done. Failure to build harmonious relationships can be fatal in the form of community rejection, including difficulties in getting community agreements (Vasquez, 2011). The existence of village institutions and village governments that have a harmonious relationship with the company can be one of the bridges to establish good communication. Another way is to prioritize the potential of local human resources in carrying out mining activities (Vasquez, 2011), as conducted by PT. Timah Tbk (PT. Timah, 2015).

The results of the analysis of this study related to the sustainability status of the tin mining environment on the social dimension, obtained a sustainability index value of 54.74% which is included in the quite sustainable category. This value indicates that the social dimension of sustainability status has met the sustainability requirements so that its management can be upgraded to a very sustainable category so that mining activities have a positive impact on the community and regional development. The results of this analysis show that the most sensitive lever attribute influences the social dimension sustainability index to be improved, namely the relationship between the community and the mining industry 8.81%, community empowerment in mining activities 6.80%, the frequency of social conflict 25%, the influence of the mine and post-mining to the socio-cultural value of the community 5.07%, and the influence of mining activities on education 5.18%. Attention to efforts to improve the status of social sustainability is carried out by paying attention to priorities in improving the relationship between communities around the mine and the mining industry, community empowerment, and attention to the frequency of social conflicts in the community.

Mining activities can be a driver of development in the region through a harmonious relationship between the company and the local community. Community empowerment is part of the concept of implementing Corporate Social Responsibility (CSR) through community empowerment through

community development programs, performance evaluation of community programs and community development programs at all stages of mining activities (Holden *et al.*, 2017; Hilson *et al.*, 2019). Mining company activities not only contribute to the economic sector, but also give social impacts to the community and the environment around its operations. Mining business players really need support from their environment, a responsive attitude towards environmental needs is needed, both the environmental demands listed in the regulation, and environmental demands that are not directly mentioned in public regulations. The success of a mining company's business today is largely determined by the success story in building public trust through the implementation of corporate social responsibility in the form of community development programs (Vasquez, 2011; Holden *et al.*, 2017; Que *et al.*, 2018; Hilson *et al.*, 2019). The results of the research of Irawan *et al.* (2014a; 2014b) and Rosyida *et al.* (2018) shows that the sustainability of the tin mining industry in Bangka Belitung is influenced by the central government, local governments, local communities, small scale mining and suppliers, producers and investors as well as law enforcement.

Gap conflicts are characterized by the emergence of perceptions of injustice in the management of a mining business. This case is common problem for community with high natural resource wealth, including tin mineral resources. The mine owner in its management tends to involve the local population very little or is considered to be non-existent or lack of contribution to the community. A company will get resistance from the community either directly or indirectly and will lead to conflicts between the company and the community that can disrupt the mining operations (Vasquez, 2011). Social conflicts that occur in society are conflicting between one party and another based on economic, cultural, political, legal, land and other motivations. The social conflict that occurred in Jebus district was still in a low limit and not worrying. One of the conflicts that occur is a conflict between local communities and migrants in the mining area, conflicts between residents based on business competition, conflicts between miners based on the struggle for tin resources. Resolving cases of conflicts that occur is carried out in various ways by the security forces, village and sub-district governments, and related parties. One of the efforts taken is deliberation at the RT or neighborhood level to make peace and toler-

ance between communities so that security and order in Jebus District is maintained, if deliberations do not produce results, efforts through legal channels are taken by reporting to the police. Thus, mining companies should see that the social approach is a long-term investment that must be carried out for the sake of the sustainability of mining operations. This opinion is reinforced by Taqwa (2012) and Hilson *et al.* (2019).

Conclusion

Tin mining in Jebus district, West Bangka regency was less sustainable with 44.39% multidimensional sustainability index. The value for the environmental dimension is 44.45%, the economic dimension is 33.97% and the social dimension is 54.74%. The index value is not sustainable due to post-mining management practices is not implemented well. This unsustainable condition is a temporary condition that can change to be quite sustainable to sustainable in the long time by encouraging the strategy and policy measure to improve the sustainability status of post-tin mining.

Some proposed policy recommendations, namely a) conducting conservation and land management programs on post-mining land. b) conducting activities to increase economic activities in the community around the post-mining area. c) increasing the economic value of ex-mining land through land conversion, such as fisheries, plantations or tourisms. d) minimizing the negative influence of mines and post-mines by involving the participation of communities around the mine through CSR programs of companies and local governments (sub-districts, districts and provinces).

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