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Evaluation of Potency and Mineral Reserve Balance for Sustainable Mining Management—Case Study: Central Java Province of Indonesia

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Abstract: The level of availability and scarcity of resources gives an indication of how to manage scarce resources. Good mining practice supports sustainability and minimizes environmental degradation. One alternative to support the development of potential mineral resources is the study of mineral resource balances. The research objectives are: (a) to evaluate the potential of mineral resources and reserves, (b) to evaluate the production data of mineral commodities, (c) to calculate mineral reserve balance. Research methodology includes an inventory of data in the Department of Energy and Mineral Resources. Compilation of mineral resource balance adjusted to the applicable regulations. The study was conducted in the Central Java Province of Indonesia. Based on the evaluation results there were 26 mineral commodities, but there were only 12 commodities developed during 2016-2018. These resources are andesite, limestone, basalt, fill-dirt, sandstone, trass, feldspar, quartz-sand, marble, diorite stone, talk and claystone. The mineral reserve supports the construction of highways, airports and other infrastructure projects in Central Java Province of Indonesia.

Key words : Mineral resources, sustainability, environment, reserves balance, contribution.

1. Introduction

Generally implementation of development is still based on the utilization of natural resources. Abundant natural resources are valuable capital for the implementation of development, but the unwise and unplanned management of natural resources has the potential to cause environmental damage and natural disasters [1, 2]. Mineral resource balance research is an initial capital for the utilization of mineral resources and for calculating the availability of resources and their potential uses. This mineral resource balance research is related to the management of natural resources that can benefit economically and environmentally [3] as well as the continuity of community welfare [4] for the present generation and future generations [5]. The level of availability and scarcity of mineral resources gives an indication of how they should manage mineral resources to ensure sustainability and minimize environmental degradation [6-8].

One alternative to support the development of the utilization of mineral resource potential is the study of mineral resource balances. Mineral resource balance research is an initial capital for the utilization of mineral resources and for calculating the availability of resources and their potential uses.

Geospatial information is a major component that must be built into sustainable development planning and is in favor of increasing economic growth [9], reducing poverty, and reducing unemployment while maintaining environmental sustainability [10].

Central Java Province of Indonesia has a variety of mining potentials, namely: gold ore, copper. In addition, there are other commodities such as phosphate marble, limestone, calcite iron sand, limestone and sandstone,

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andesite, fill-dirt, sandstone. Data from the mining sector can be used as input for local government in regional development and accelerate development through efforts to use commodities in the area. Tax revenue from the mining sector can be obtained optimally [11], so as to improve the welfare [12] and income of the people in the area [13].

This mineral resource balance research includes data on reserves and production of mining commodities in 35 districts in Central Java Province. This study aims to evaluate the potential of non-metallic mineral resources in Central Java Province of Indonesia and to make a non-metallic mineral balance sheet. Decision makers can utilize the results of research for the management of the mining industry in Central Java Province [14, 15].

2. Method and Material

Primary data are field research data such as interviews and focus group discussions, while secondary data are obtained from the Department of Energy and Mineral Resources of Central Java Province of Indonesia. Raw data are the distribution of potential mining commodities and non-metallic mineral resources in each district in Central Java Province.

Data compilation of the calculation of non-metallic mineral resource potential was carried out in 35 districts in Central Java Province of Indonesia, making thematic maps showing the distribution of non-metallic mineral potential in Central Java Province using the ArcGIS application [16-18]. Fig. 1 shows flow chart for creating a map of potential resources and reserves.

Preparation of mineral reserve balance is based on Indonesian National Standard No. 6728.4: 2015. The mineral balance sheet is a mineral reserve evaluation tool, which presents initial reserves, changes/uses, and the level of environmental damage due to exploitation as a factor of environmental degradation and financing as well as the final state in the form of mineral

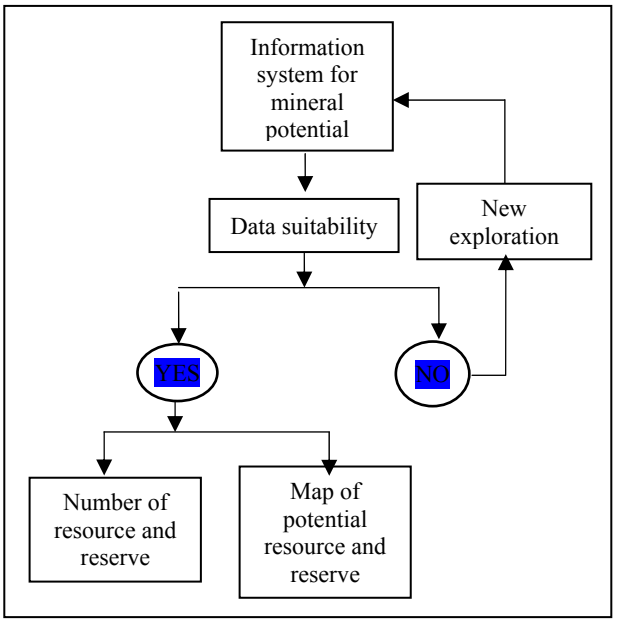

Fig. 1 Flow chart for creating a map of potential resources and reserves.

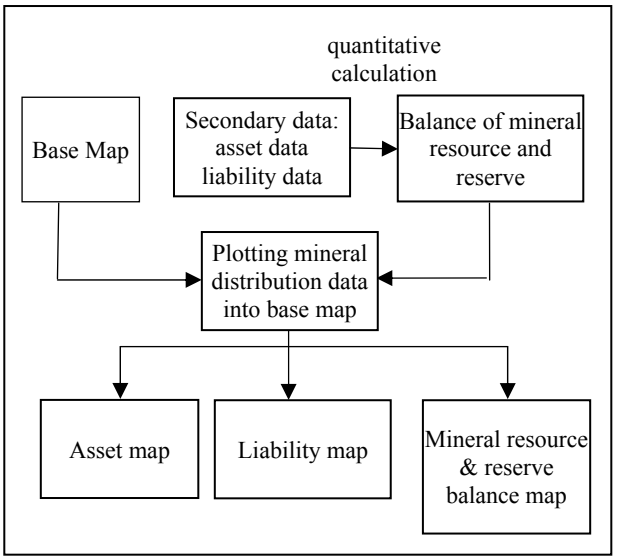

Fig. 2 Flow chart of mineral resource and reserve balance.

distribution tables and maps. Balance sheet analysis requires mineral reserve data, and mining commodity production in all districts in Central Java Province. Fig. 2 shows a flow chart of mineral resource and reserve balance.

To fill the annual production data inventory the downward column model for minerals is used, while the right column is the year of production. The production year column is the sum of all production

for each commodity recorded.

Grammatical understanding of mineral resource balance is as scale arranged to find out the amount of initial reserves stated in assets and the amount of utilization expressed in liabilities, so that changes in reserves can be known the amount of reserves remaining stated in balances an area and within a certain period of time. The main principle of mineral resources balance is to provide information on mineral resources which includes:

∑SADn = mineral resource inventory in the current year;

∑SADn□ = supply of mineral resources in the early years.

Depletion SADn is the difference in the supply of mineral resources in the early years minus the current supply of mineral resources. Depletion of mineral natural resources is explained in the following formula:

$$SADn = \sum SADn\square - \sum SADn$$

3. Result and Discussion

One of the information system's products in the mineral resource database is a map of mineral resource potential which is a form of expression of data and information resources in an area or region. This map will provide information on the distribution and types of resources presented with colors, symbols, letters and numbers. Fig. 3 shows map of potential non-metallic mineral resources in Central Java Indonesia.

Based on this research, 12 potential mineral resources are very prospective to be developed. These commodities are andesite, limestone, fill-dirt, claystone, sandstone, quartz-sand, diorite, feldspar, marble, talk,

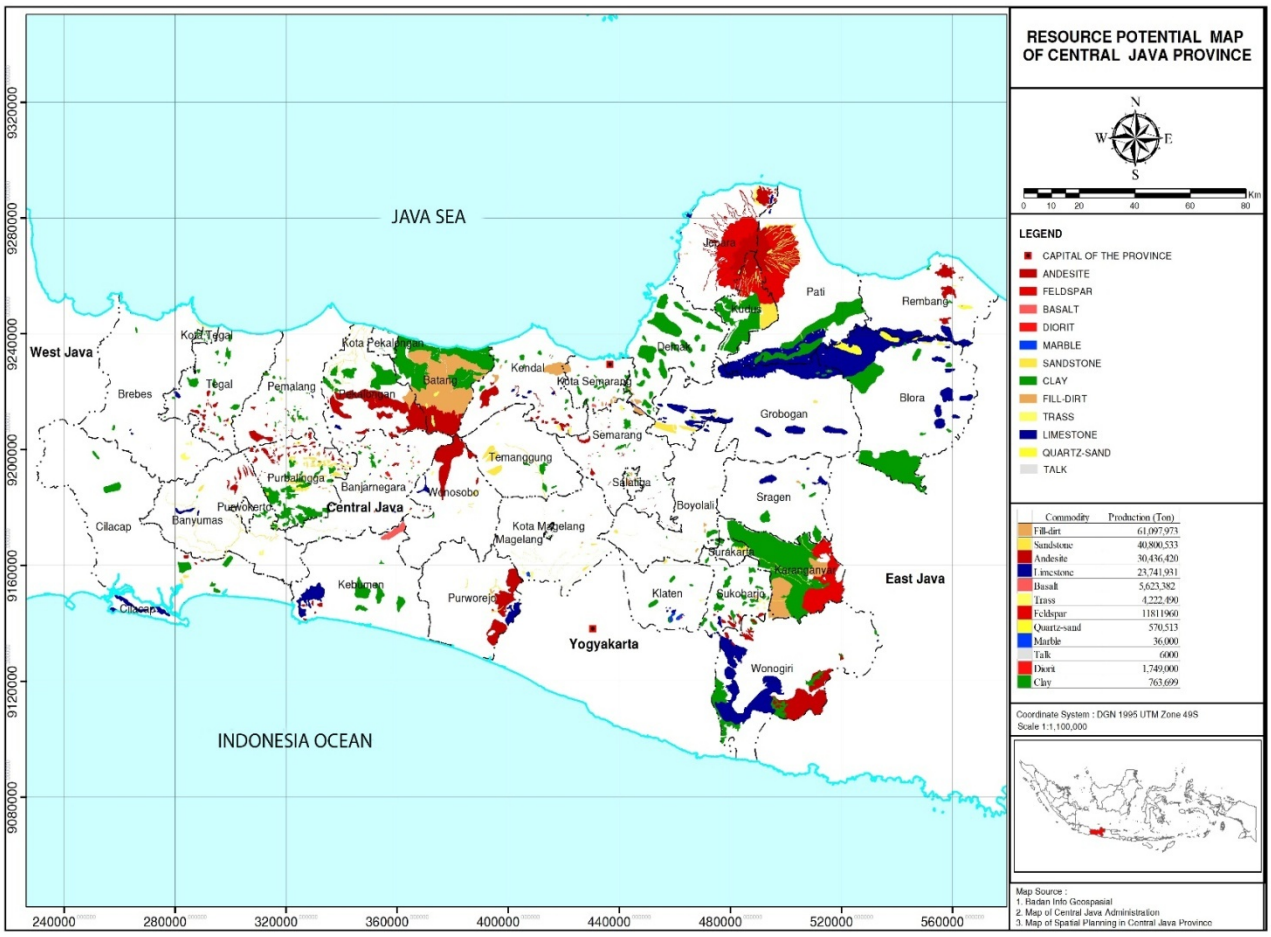

Fig. 3 Map of potential non-metallic mineral resources in Central Java.

Table 1 Mineral commodity reserve data.

No.	Commodity	Reserve (ton)			Total reserve (ton)
		2016	2017	2018	
1	Fill-dirt	89,831,062	71,515,412	46,908,853	208,255,327
2	Sandstone	986,775,700	98,114,491	41,645,288	1,126,535,479
3	Andesite	44,211,044	51,657,447	49,818,980	145,687,471
4	Limestone	93,323,755	78,033,061	2,190,154,747	2,361,511,563
5	Basalt	9,014,490	7,658,616	5,795,505	22,468,611
6	Trass	720,020	19,412,707	20,544,946	40,677,673
7	Feldspar	59,279,072	26,342,193	9,658,256	95,279,521
8	Quartz-sand	751,275	2,217,571	10,149,706	13,118,552
9	Diorite	3,658,973	2,225,868	794,953	6,679,794
10	Marble	100,000	85,000	60,000	245,000
11	Talk	15,000	8,000	3,000	26,000
12	Clay	573,709	930,908	17,721,100	19,225,717

trass and basalt (Table 1). The obstacle faced in the preparation of the potential of non-metallic mineral resources and rocks is the incompatibility between the value of resources with a map of the distribution of potential resources. Some maps of non-metallic mineral resources and rocks in districts in Central Java (not discussed in this paper) show there are no potential mineral commodities, but there are data on resource potential.

The resulting map is inaccurate due to the asynchronous exploration of mineral resource discovery data and the making of maps of mineral resource potential. For this reason, further research is needed in the form of new exploration in an effort to obtain more accurate data on the potential of mineral resources. Fig. 4 shows map of mineral reserve asset.

Inconsistency between the value of potential resources and maps of the distribution of potential mineral resources is a review of the regional spatial plan which is carried out every 5 (five) years since the promulgation of the regional spatial plan. Mining allotment areas are determined with the following criteria: (a) there are mining resources that are solid, liquid or gas based on maps or geological data; (b) the area can be utilized for the concentration of mining activities in a sustainable manner; and/or, (c) there is a part of the process of changing potential economic forces into real economic forces.

Regulations from the Government state that there are zoning provisions for mining areas, namely: (a) arrangement of mining areas based on a balance between costs and benefits and a balance between risks and benefits; (b) regulating the mining area by utilizing karst areas according to the carrying capacity of the karst ecosystem.

Based on the above rules, the distribution map of potential mineral resources is adjusted to the potential value of exploration studies in mining areas in the Central Java Province of Indonesia.

Another problem is the overlap between the mining area and other utilization areas. The solution is to maintain the sustainability of other areas, by providing space in the mining area. Opportunities for wider and more flexible space for mining activities have actually been regulated in the law, namely the granting of a lease-to-use permit that has a significant impact and broad scope and strategic value by the Minister with the approval of the House of Representatives.

Map of the potential of non-metallic mineral resources and rocks is very important and needed for promotional materials by the Department of Energy and Mineral Resources to investors in the context of infrastructure development in Central Java Province.

Every year the amount of resources is updated based on the discovery of new mineral commodity

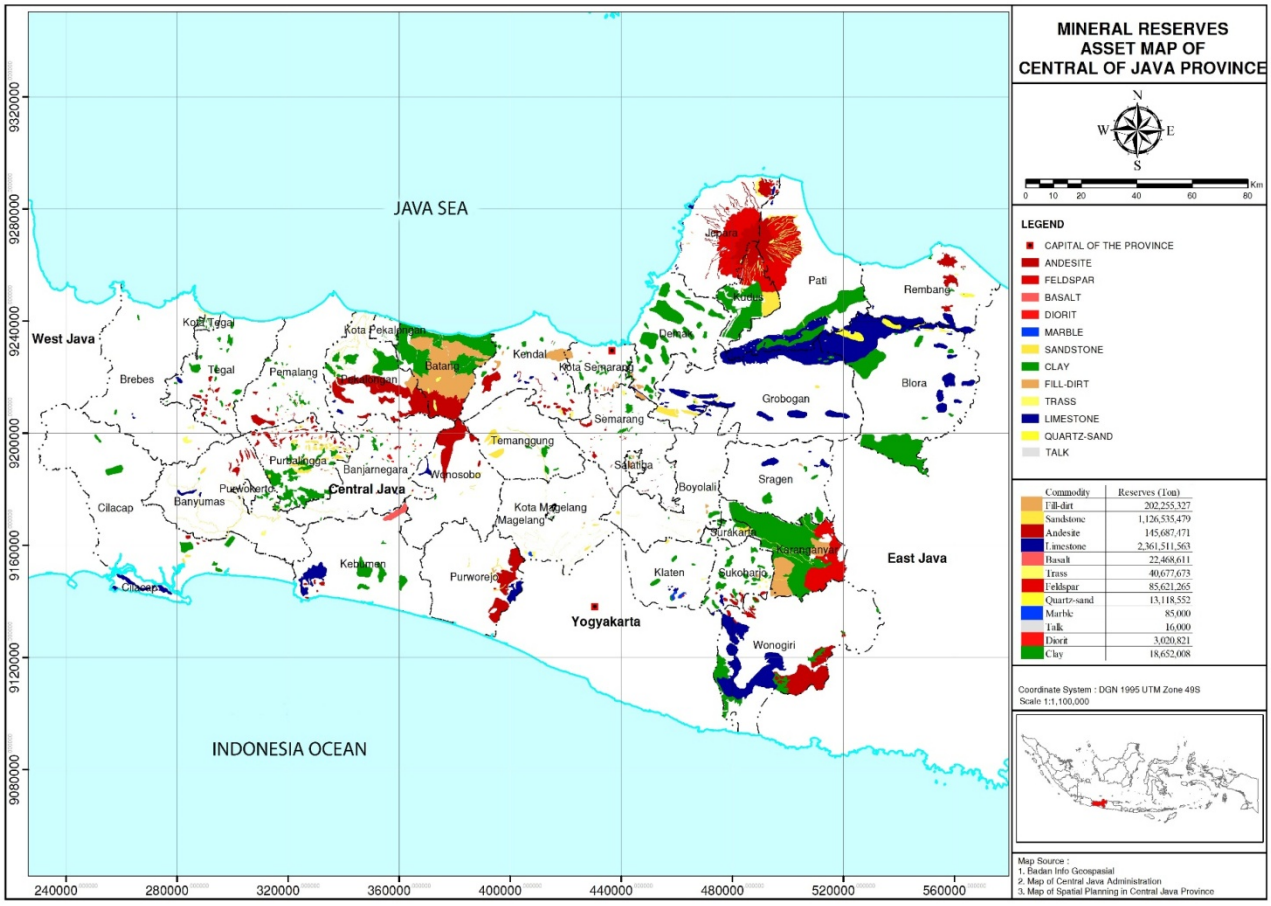

Fig. 4 Mineral reserve asset map.

resources (Fig. 5). Very urgent needs are information on mineral economic forecasts, integration, coordination and synchronization of related institutions, including: the Ministry of Energy and Mineral Resources, the Center for Geological Resources, the Central Statistics Agency, the Directorate General of Mineral and Coal, the Ministry of Industry, the Ministry of Trade, as well as from the data and information center of Ministry of Energy and Mineral Resources.

Based on this research, mining management efforts are: (a) further improving independent and competitive mining management; (b) giving more value to mining; (c) giving a limit to the authority of regional autonomy in mining management; (d) further enhancing the management of mining that is environmentally sound; and (e) further guaranteeing sustainable national development. Non-metallic mineral resources and rocks have high potential to enhance the economic recovery of the community. These resources are generally easier to find, easier to mine, smaller capital and need a shorter time to explore. In addition, the management of these commodities does not require complicated technology. Several types of mining commodities can be used directly without going through processing.

Based on the balance sheet of non-metallic mineral resources and rocks in Central Java Province, the reserve balance and economic value of these resources can be evaluated. The government determines policies to regulate and utilize the benefits of these resources more optimally. In addition to supporting the development of sustainable national infrastructure, as well as the conservation and preservation of ecosystem functions, which are related to the use of non-metallic minerals and rocks. The benefits of this resource balance will be more optimal if the preparation is carried out periodically, a more thorough analysis,

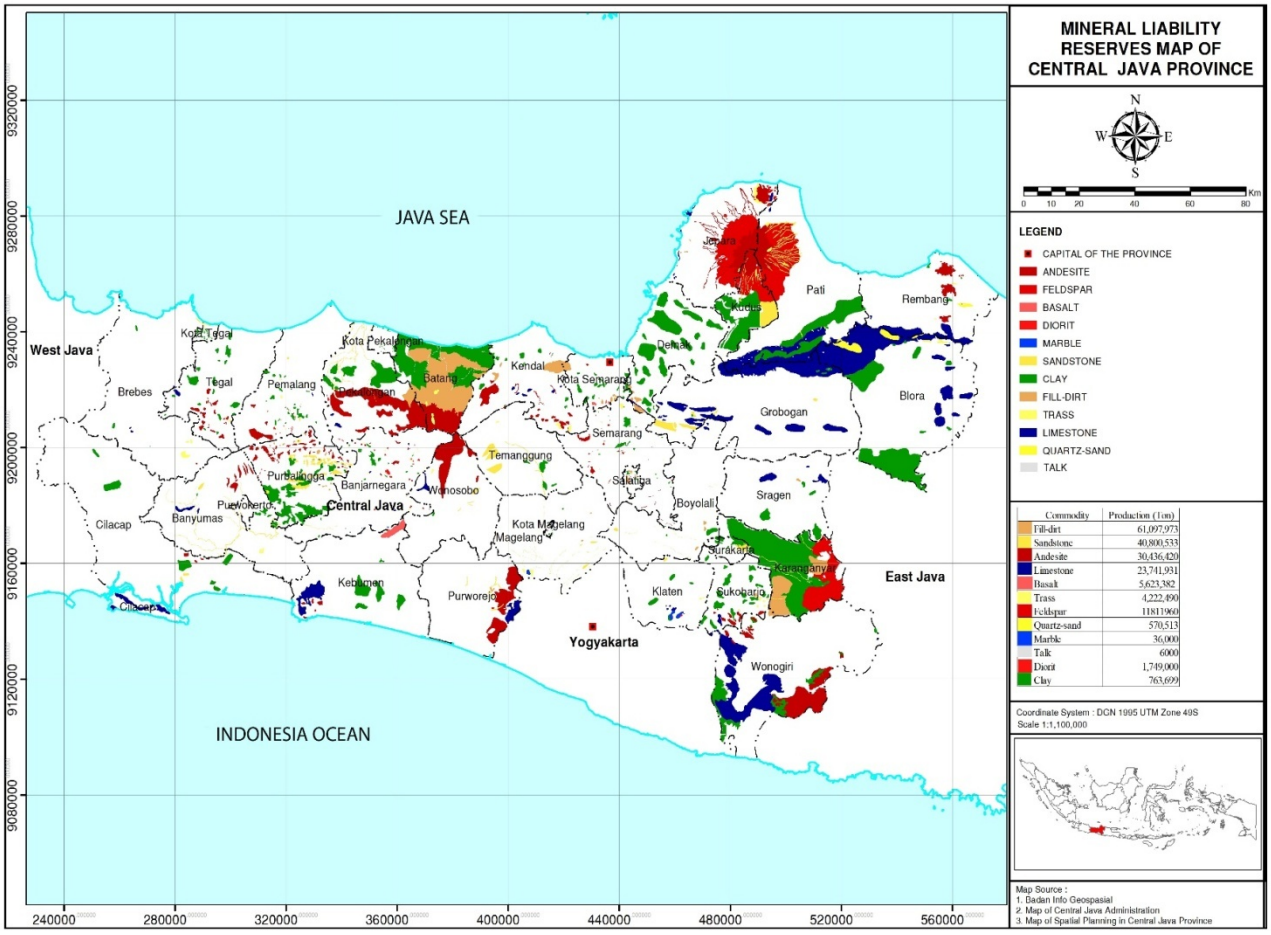

Fig. 5 Mineral liability reserves map.

economic validation is carried out in more detail, and integrated, synchronized and coordinated with all stakeholders related to the management of mineral resources.

The preparation of the mineral resource balance is an evaluation tool to present initial reserves, changes/uses, and the level of environmental damage due to exploitation as a factor of environmental degradation and financing as well as the final state in the form of tables and maps of mineral distribution. Initial reserves (assets) are preliminary data of each type of mineral commodity contained in each administrative area/area. Data continue to grow for one year during exploration activities. Mineral reserve data are changing or increasing dynamically.

Final reserves (liabilities) are data of each type of mineral commodity resulting from the exploitation/use of the commodity, including depreciation and externalities at the end of the calendar year. Based on these assumptions, the resource balance can be analyzed, to find out the remaining reserves as final reserves (Fig. 6).

Based on the analysis of the availability of resources, reserves and mineral production activities can obtain mineral balance index in Central Java, Indonesia. The mineral resource balance sheet is compiled based on an evaluation of the results of an inventory of data covering at least two compilation periods, so that changes can be identified. In the form of descriptive statistics, mineral resource balance (Fig. 6) is presented in a discount table format, which is a table of potential (assets, see also on Fig. 4) in the left column and utilization (liabilities, see also on Fig. 5) in the right column.

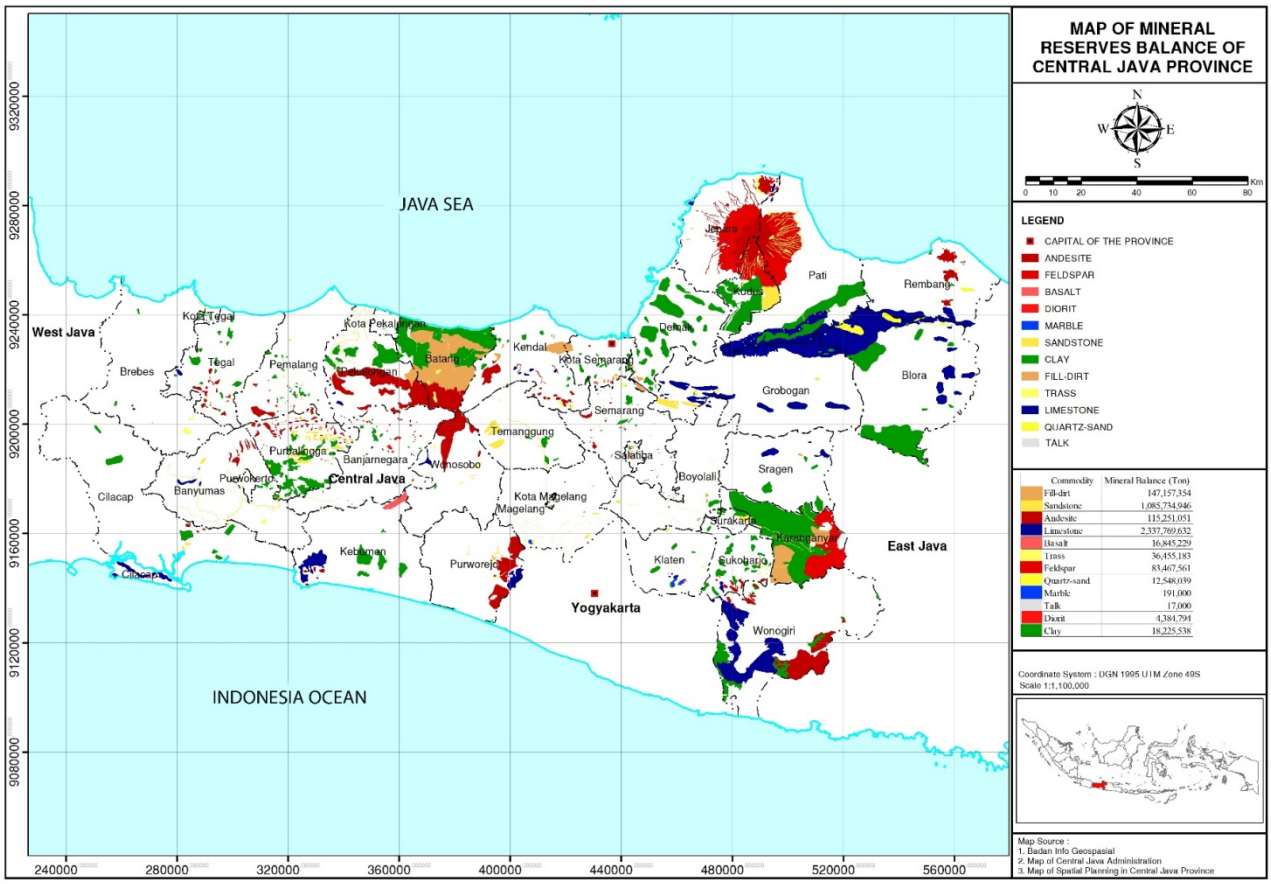

Fig. 6 Map of mineral reverse balance.

Table 2 Mineral commodity production data.

No.	Commodity	Production year (ton)			Total production (ton)
		2016	2017	2018	
1	Fill-dirt	21,816,154	16,569,394	22,712,426	61,097,973
2	Sandstone	8,685,804	17,325,800	14,788,928	40,800,533
3	Andesite	15,915,489	6,525,958	7,994,973	30,436,420
4	Limestone	13,795,850	2,522,150	7,423,931	23,741,931
5	Basalt	727,500	1,661,883	3,233,999	5,623,382
6	Trass	168,480	2,780,750	1,273,260	4,222,490
7	Feldspar	11,327,160	386,800	98,000	11,811,960
8	Quartz-sand	250,425	79,500	240,588	570,513
9	Diorite	546,000	742,000	1,007,000	2,295,000
10	Marble	18,000	18,000	18,000	54,000
11	Talk	3,000	3,000	3,000	9,000
12	Clay	236,480	253,545	510,154	1,000,179

Balance sheet calculation is based on reserve data and production data (Table 2) where the amount of mineral reserves in 2016 was reduced by the amount of production in 2016 so that the remaining reserve balance was obtained in 2016. Then in 2017, the reserve balance in 2016 was added with new reserves in 2017 obtained from permit approval mining operations in production operations in 2017, reduced by the number of production in 2017, so that a reserve balance was obtained in 2017. In 2018, the total

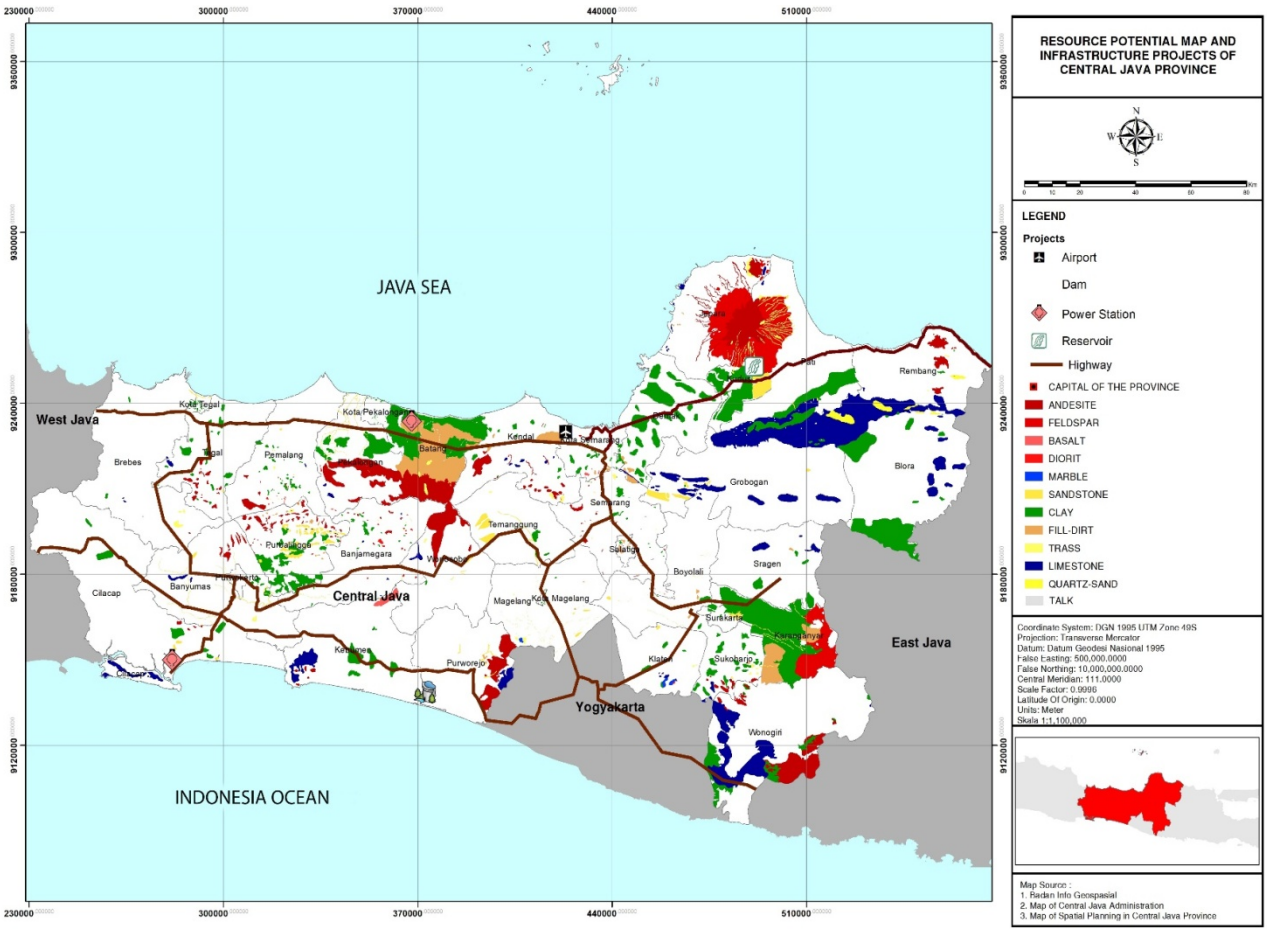

Fig. 7 Map of infrastructure in Central Java Province of Indonesia.

reserve balance in 2017 was added with the number of new reserves in 2018, and reduced by production in 2018 to obtain a reserve balance in 2018 (Table 2).

The highest amount of reserves in 2016-2018 was limestone commodities with total reserves of 2,361,511,563 tons and production of 30,436,420 tons, so that the reserve balance in 2018 was 2,337,769,632 tons. Sandstone commodity has reserves of 1,126,535,479 tons with production of 40,800,533 tons, the remaining reserves are 1,058,734,946 tons, fill-dirt commodities with 208,255,327 tons of reserves and production of 61,097,973 tons; the remaining reserves are 147,157,254 tons, and andesite commodities with reserves of 145,687,471 tons and production of 30,436,420 the remaining reserves are 115,251,051 tons. Table 3 shows the balance sheet of mineral in Central Java Province of Indonesia.

Based on the analysis of mineral reserve estimation, Central Java Province has a large remaining mineral reserves, so that exploitation activities can be carried out in the future (Fig. 8) by optimally utilizing the remaining mineral commodity reserves. Fig. 8 shows management for a sustainable mining industry with an environmental perspective in Central Java Province Indonesia.

Based on the priority of the development program by the central government, especially in the field of infrastructure, namely the construction of highways, airports and seaports are good opportunities for mining commodity utilization (Fig. 7). These conditions have an impact on increasing the production of mining commodities, especially as raw materials in infrastructure development. The development has a role in encouraging economic growth.

Table 3 Balance sheet of non-metallic mineral and rock reserves in Central Java.

No.	Commodity	Resource				Total resource	Reserve		Total reserve	Production	Mineral balance
		Hypothetic	Inferred	Indicated	Measured		Probable	Proved			
1	Fill-dirt	34,189,326,664	12,400,000	-	150,662,372	34,352,389,036	-	206,255,327	200,255,327	61,097,973	147,157,354
2	sandstone	6,273,176,169	1,816,941,074	-	18,087,687	8,108,204,930	-	1,126,535,479	1,126,535,479	40,800,533	1,085,734,946
3	Andesite	3,556,731,343,000	2,896292,644	-	67,628,366	3,559,695,264,010	-	145,687,471	145,687,471	30,435,420	115,251,051
4	Limestone	160,566,061,082	8,770158,918	-	513,938,969	169,819,161,959	-	2,361,511,593	2,361,511,663	23,741,931	2,337,769,632
5	Basalt	511,087,345	-		18,854,100	529,941,445	-	22,458,511	22,468,611	5,623,382	18,045,229
6	Trass	658,337,874	42,136,624	-	-	700,474,498	-	40,677,673	40,677,673	4,222,490	35,455,183
7	Feldspar	66,504,000	145,014,026	-	145,224,932	356,742,950	-	95,279,521	95,279,521	11,811,960	83,467,561
8	Quartz-sand	2,216,880,000	138,163,000	-	751,275	2,355,794,275	-	13,118,552	13,118,552	570,513	12,548,039
9	Marble	260,029,987	18,588,000	-	-	278,618,787	-	245,000	245,000	54,000	191,000
10	Talk	31,628	-	-	-	31,625	-	26,000	26,000	9,000	17,000
11	Diorite	515,270,350	773,861,000	-	-	1,289,131,350	-	6,679,794	6,679,794	2,295,000	4,304,794
12	Clay	11,665,351,825	1,258,565,084	454,880,000	-	13,378,796,909	-	19,225,717	19,225,717	1,000,179	18,225,538

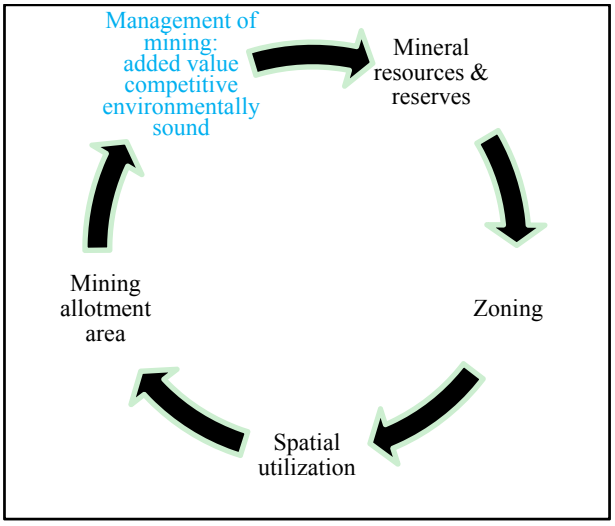

Fig. 8 Management of mining allotment with environmental perspective.

4. Conclusion

Based on research on resource potential, there are 12 non-metallic mineral commodities and rocks in the Central Java Province of Indonesia. Re-mapping the potential of mineral resources needs to be done to align between potential values and the distribution of potential mineral resources. The Department of Energy and Mineral Resources of Central Java Province uses the data to make policies related to investments in non-metallic mineral and rock mining.

Based on the evaluation of production data, fill-dirt, sandstone, andesite, and limestone commodities are leading commodities in the Central Java Province of Indonesia. Infrastructure development is a good opportunity for the utilization of mining commodities in driving economic growth. Department of Energy and Mineral Resources of Central Java Province needs to create a data base system related to the presence of non-metallic mineral and rock resources that can be accessed by the public and investors.

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