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# A Cost-Benefit Analysis of Mapping Used Cooking Oil as Biofuel Feedstock for Small-Scaled Industries

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***Abstract***

*The abundant availability of used cooking oil as feedstock for biofuel can be used as potential for developing renewable fuel. Throughout 2021 alone, used cooking oil production originating from household sector is estimated to have reached 3.59 kilo liters or equivalent to 22.52% of total contribution achieved. The aim of this research is to determine the feasibility of used cooking oil as a feedstock for biofuel by measuring how much biofuel can be produced from household waste and how many small-scaled industries can be formed by considering an equal financing scheme between provinces. This research uses a cost-benefit analysis to produce a ratio that can calculate benefits against costs. The cost factor is calculated by estimating the expenses required to produce biofuel, while the benefit factor uses from Kartu Pra Kerja distribution data. Result can be concluded that the program is feasible to implement because it produces benefit to cost (BC) ratio of 1.31 with an estimated of 983,191 kilo liters biofuel can be produced and 234,093 small-scaled industries can be formed. Meanwhile provincial mapping showed that only six provinces in Indonesia that are considered unpotential for developing programs because BC ratio < 1.*

**Key words** : Used Cooking Oil, Feedstock, Biofuel, Cost-Benefit Analysis, Small-Scales Industries, Provincial Mapping

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## INTRODUCTION

Indonesia's economy is increasingly growing in line with the recovery after COVID-19 pandemic, which is marked by an increasing decline in the number of patients suffering. The recovery of the national economy will inevitably contribute to an increase in basic needs, especially those related to social mobilization. Indonesia itself has lifted the implementation of Pemberlakuan Pembatasan Kegiatan Masyarakat (PPKM) as an effort to limit social interaction in preventing the spread of the virus during the pandemic. The implementation of PPKM previously had a major impact on slowing the growth of several economic sectors, especially transportation. Based on the Handbook of Energy and Economic Statistics of Indonesia in

2021, the fuel consumption (fuel oil) throughout 2020 decreased by 11.51% compared to 2019 (KESDM, 2021).

Unfortunately, the sloping graph of fuel consumption only occurred throughout 2020 because entering 2021 fuel consumption rose to 7.06% in line with the improvement in post-pandemic conditions (Ministry of Energy and Mineral Resources Republic of Indonesia, 2022). Hopes for post-pandemic economic recovery are unfortunately not in line with the improvement of the global economy. The outbreak of war conflict between Russia-Ukraine and soaring world consumption have contributed to increase world oil prices. It obviously had a major impact domestically because Indonesia is a net importer of oil and gas (Monita & Andriyani, 2021), where the amount of domestic demand is still relatively higher than the amount of production produced for export commodities.

Dependence on high domestic fuel consumption has forced the government to prepare budget reserves to anticipate global uncertainty due to rising world oil prices Therefore, it is important to implement the renewable energy transition scheme immediately in order to help the government reduce the size of budget subsidizing fuel. Efforts to reduce the government burden in fulfilling fuel subsidies, one of which can be done through the use of renewable fuels. The use of renewable fuels will prove the government's commitment to participate in reducing world carbon emissions produced from fossil fuels.

The "Sustainable Energy Transition" is one of the three priority agendas of the G20 which took place in Indonesia in November 2022. Countries all over the world have committed to changing energy use from non-renewable energy to renewable energy, including fuel use. As an effort to replace fossil fuels, it is important to consider the sustainability factor of the raw material potential (feedstock). Indonesia has the option to develop alternative renewable fuels using vegetable oil known as biofuel (Wafi & Budianto, 2022). One of the biofuel raw materials that can be used comes from palm oil or CPO (Crude Palm Oil). Biofuels made of CPO has great potential because Indonesia is a country with the largest CPO production in the world (United States Department of Agriculture, 2023).

Domestic CPO production is increasing every year due to the increasing consumption of cooking oil. The truth is, the consumption of cooking oil in Indonesia in 2021 has reached 18.50 million tons or equivalent to 14.85 kilo liters (GAPKI, 2022), and of which 22.52% came from household consumers (BPS, 2022). Even though Indonesia has great potential for developing biofuels with abundant raw materials, it is still faced with the problem of increasing CPO prices (Nafisah & Amanta, 2022). The increase in CPO prices is influenced by increased global market demand so that it becomes an excellent commodity as the country's largest foreign exchange earner.

The potential for CPO as a raw material for biofuels can be replaced with other vegetable oils, such as corn oil, soybean oil, coconut oil, or even the residue from the oil consumption. The residual vegetable oil that has a large supply in Indonesia is used cooking oil. This oil is the by-product of the consumption of cooking oil used daily by the community. To a certain extent, the majority of people still consider used cooking oil as waste that has no economic benefits, so it is only disposed of using conventional methods which can pollute the environment. Surprisingly, with current technological developments, used cooking oil can be used as biofuel feedstock which has high economic value while producing low levels of carbon emissions (Wafi & Budianto, 2022).

The amount of used cooking oil from its previous consumption is 40-60% (Ministry of Energy and Mineral Resources Republic of Indonesia, 2022). This means that for every use of 1 liter of cooking oil, the potential for leftovers

in the form of used cooking oil are as much as 0.4-0.6 liters. Badan Pusat Statistik (BPS) released data on average consumption of cooking oil per week per capita in Indonesia of 0.25 liters. It is estimated that as much as 3.59 kilo liters of used cooking oil per year can be produced from household consumption. Along with technological developments, techniques for processing used cooking oil as raw material for biofuels have been varied. One of them is through the transesterification method which can produce a processing ratio of up to 0.7%. This means that every 1 liter of used cooking oil can produce 0.7 liters of biofuel (Ula & Kurniadi, 2017).

The potential for used cooking oil as a raw material produced from the household sector has not been balanced with knowledge of proper processing techniques. Even though the stock of used cooking oil from the household sector is considered potential, there have even been several previous studies that have measured the processing through the small-scale industries (Ula & Kurniadi, 2017). A small-scale industries can be formed from a group of people who are actively involved in the business of processing used cooking oil as a raw material for biofuels. Besides being useful in increasing awareness and concern for environmental ecosystems, these activities also provide added value to the community's economic activities.

Small-scale industries efforts need to get attention from the government, especially in terms of financing because it requires a lot of funds. Its financing scheme is considered to have a significant impact since it starts from the smallest social unit, in this case community groups empowered to become business groups. In addition, the aspect of representation between regions also needs to be taken into account. It aims at avoiding the program to only focus on development in certain areas because it cannot create a gap. Mapping potential areas based on provinces of Indonesia using cost-benefit analysis can be a solution to see the repr-esentation of regional equity.

The cost-benefit analysis method can be used to calculate a ratio in comparing benefits against costs. The cost factor is calculated by estimating the expenses required to produce biofuel such as fixed cost, variable costs, and investment costs (Ula & Kurniadi, 2017). Meanw-hile, the benefit factor is using labor-intensive financing through a social assistance program known as *Kartu Pra Kerja* (Rawie & Samputra, 2020). The use of *Kartu Pra Kerja* is considered a community social assistance system that is right on target and labor intensive so that it will provide more tangible benefits in improving people's living standards.

The aim of this research is to determine the feasibility of used cooking oil as a feedstock for biofuel by measuring how much biofuel can be produced from household waste and how many small-scale industries can be formed by considering an equal financing scheme between provinces. Research can provide a description of this matter to formulate policies regarding options for developing long-term financing schemes for energy transition programs with low carbon emissions.

## METHOD

In carrying out this research, various sources were used to obtain the secondary data, such as BPS, the Coordinating Ministry for Economic Affairs of the Republic of Indonesia, and previous researches. The data consisted of several variables broken down by province of Indonesia.

All six variables (table 1) were applied to assess each province. Afterwards, the collected data were processed using cost-benefit analysis to determine provinces which had financial feasibility in utilizing used cooking oil as a raw material for biofuels by small-scale industries.

**Table 1.** Research Variables

| Variable | Unit |
|---|---|
| Average Weekly Per Capita Consumption of Cooking Oil by Province | Liter |
| Total population | People |
| Number of Pre-Employment Card beneficiaries | People |
| Pre-Employment Card Training Assistance | IDR |
| Pre-Employment Card Incentive Fund | IDR |
| Pre-Employment Card Survey filling out incentive fund | IDR |

The used cooking oil processing requires costs to produce biofuel. Then, benefits were calculated to determine the earnings for the business doers in each province of Indonesia. Based on this description, the framework was designed as follows:

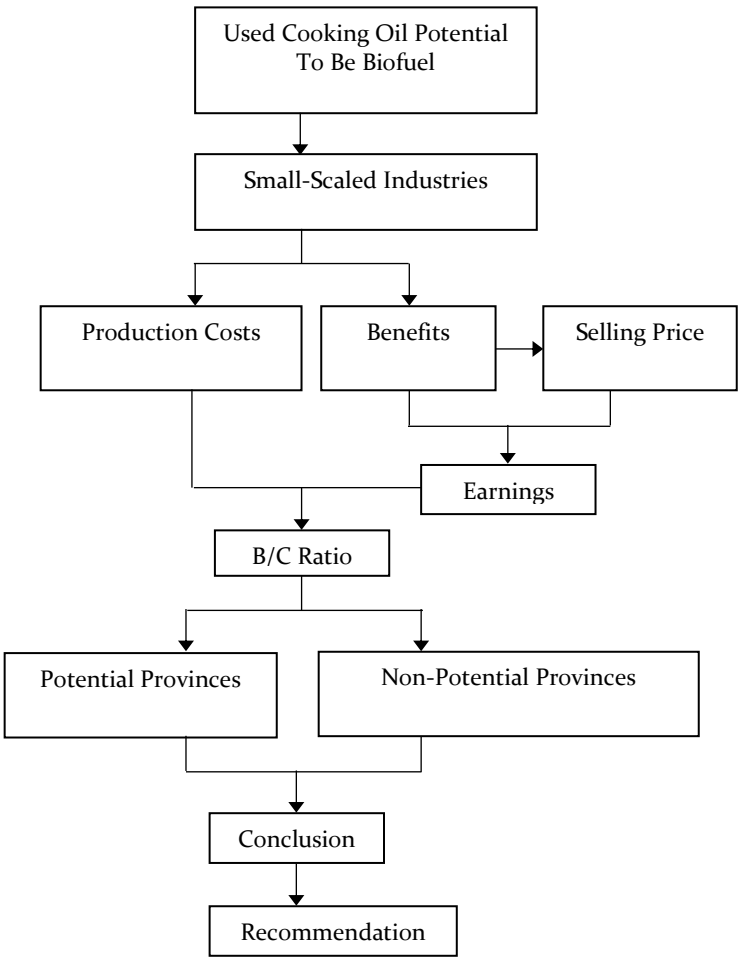


**Figure 1.** Framework

A Cost-Benefit Analysis is an approach to recommend policies or programs that allow by comparing and suggesting the implementation of a policy or program or estimate the impact of a policy or program by calculating the total costs in terms of money and the total benefits in terms of money/monetary (Dunn, 2018). It is in line with Schniederjans et al in Christian (Christian et al., 2013) who mentions that Cost-Benefit Analysis is a technique for analyzing costs and benefits that involves estimating and evaluating the benefits associated with alternative actions to be taken.

The costs and benefits analysis in this study used the B/C ratio method. The B/C ratio is a comparison between total revenue and total costs, showing the value of revenue earned for each IDR spent. The B/C ratio formula used was:

$$B/C\ ratio = \frac{total\ earnings\ (B)}{total\ production\ costs\ (C)} \quad (1)$$

The resulting criteria can be interpreted as follows: (a) B/C ratio > 1, The B/C ratio can evaluate the feasibility of a project by providing a clear picture of whether the benefits of the project will exceed compensation for costs incurred so that the program is worth running.means the project is declared feasible to run; (b) B/C ratio < 1, On the other hand, if the B/C ratio is less than 1, it indicates that the costs required for a project exceed the benefits that will be received, so it is not feasible to carry out.

The cost-benefit analysis in this study was used to measure the level of feasibility the development of small-scale industries which processed used cooking oil into biofuels in Indonesia. In addition, this analysis functioned to develop the potential of each Indonesia province. In details, the assumptions of the cost-benefit analysis used in this study were as follows: (1) The cost-benefit analysis implemented in this study placed households as actors in the used cooking oil supply chain in small-scale industries development scheme; (2) Cost-benefit analysis simulation was carried out on the object of analysis, namely 34 provinces of Indonesia; (3) If the variable used as the object of the scale coverage analysis was lower than the province, an aggregation was carried out to produce a variable for the provincial level; (4) The cost and benefit components used in this study were assumed to be the same for each province.

The details of the cost components used in this study included: (1) Fixed Expenses, are costs that must be spent and the amount is not affected by the number of products produced. The details of monthly fixed costs are as follows: equipment depreciation per year, electricity, and labor; (2) Variable Expenses, are the amount affected by the number of products produced: used cooking oil as raw material, sodium hydrox-ide (NaOH), and methanol; (3) Investment Costs, the fixed expenses in the business of producing biodiesel from used cooking oil are as follows: plastic drum (oil storage) and 1 set of biodiesel reactor with a capacity of 50 liters. The details of the benefit components are as follows: utilization of training assistance, utilization of incentive funds, and utilization of survey filling incentive funds.

## RESULT AND DISCUSSION

Research on used cooking oil as feedstock for biofuel has been carried out previously (Lisa, 2020; Agus, 2021; and Ida, 2020). However, these studies only focus on developing catalysts for the process of making used cooking oil into biofuel. There has been no research that focuses on the potential of used cooking oil from household waste in each province. The research that has just been conducted is limited to the use of programs through communities in an area (Amelia Naim Indrawijaya, 2020) (Natalia Erna S, 2017). The potential for using used cooking oil as feedstock for biofuel can be calculated in terms of the average data of cooking oil consumption per capita per province released by BPS. These data were derived from a national socio-economic survey held twice a year whose respondents were households all over Indonesia.

In 2021, the average weekly consumption of cooking oil per capita in Indonesia reached 0.25 liters, or increased 8.45% from the previous year. This datum was then converted to see the potential of used cooking oil with an extraction ratio of 70%. After that, regional mapping was carried out based on the potential for used cooking oil produced by each province of Indonesia (Figure 2).

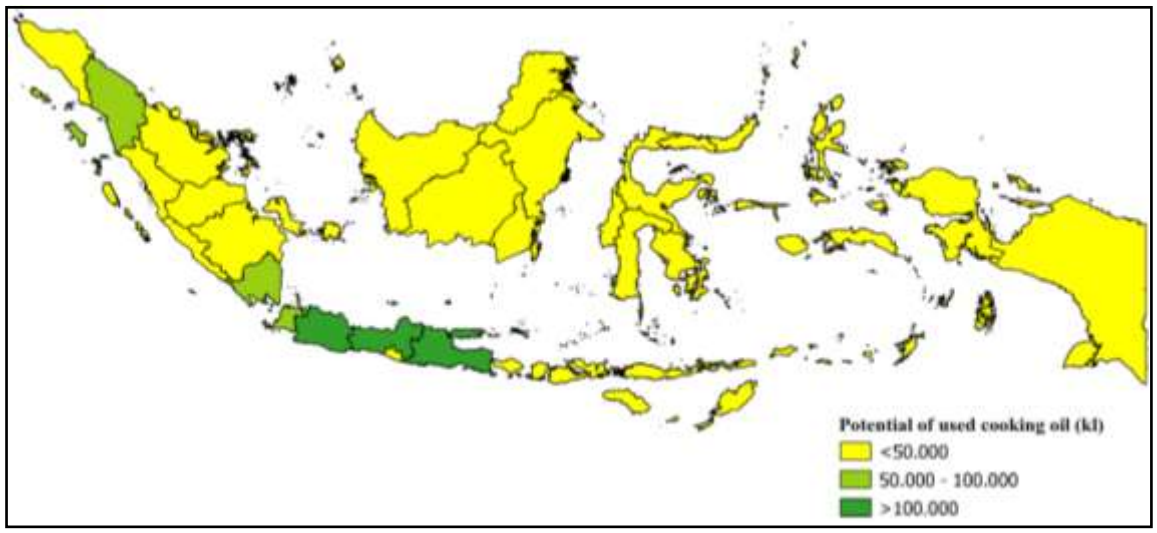


**Figure 2**. The Potential of Used cooking Oil in Provinces of Indonesia (kilo liters)

Of the provincial mapping, there were three provinces which had the highest potential for used cooking oil or above 100,000 kilo liters per year, namely: West Java (240,654 kilo liters), Central Java (188,865) and East Java (213,893 kilo liters). Meanwhile, the provinces with the lowest potential for used cooking oil were North Kalimantan (3,409 kilo liters), North Maluku (4,863 kilo liters) and Papua (5,684 kilo liters). The potential for used cooking oil in each province was then converted back into potential biofuels that can be produced. From previous researches, it can be concluded that by using the transesterification method, the potential for biofuels that can be extracted from used cooking oil is 70% (Ula & Kurniadi, 2017).

Expenses calculation are: (1) Fixed expenses, Fixed expenses covered: asset depreciation, electricity consumption and labor payments. Asset depreciation expenses were assumed to be 10% of the asset price (in the form of a processing reactor). The total fixed expenses required in processing used cooking oil into biofuel was IDR 491 per liter; (2) Variable expenses, Variable expenses included the raw material for used cooking oil, including the catalyst/additives (NaOH and methanol) in the processing process. The total variable cost required in processing used cooking oil into biofuel was IDR 6,260 per liter; (3) Investment costs, The costs consisted of the machines and tools used in the processing. The total investment cost required in processing used cooking oil into biofuel was IDR 4,515 per liter; (4) Training fees, It was assumed that IDR 1,000,000 was allocated for each small-scale industries.

Calculation of Benefits, A kind of social assistance programs related to fulfilling labor-intensive needs can be done through *Kartu Pra Kerja* (Asia, 2021). *Kartu Pra Kerja* program is considered to have similar characteristics and objectives to the program for developing small-scale industries processing used cooking oil as feedstock for biofuels. The programs have been implemented in recent years using quotas for provincial areas in Indonesia so that it can be compared with the calculation of the cost biofuel processing conversion from used cooking oil per province in the aim of creating opportunities for social equity. The card beneficiaries in 2021 received assistance worth IDR 3,550,000 with the following details of the financing: (1) Training assistance, Provided in the form of training through a third party with an amount of IDR 1,000,000 per person; (2) Incentive fund, Given in cash to beneficiaries in the amount of IDR 2,400,000 per person; (3) Survey Completion Incentive Fund, Given in cash in the amount of IDR

150,000 after the beneficiaries have filled out a predetermined survey.

**Table 2.** Amount of Benefit Cost (IDR)

| Components | Total |
|---|---|
| **Fixed expenses** | 689,638,124,967 |
| **Variable expenses** | 8,792,534,953,752 |
| **Investment Cost** | 6,341,580,721,436 |
| **Training Fees** | 234,093,049,887 |
| **Total cost** | 16,057,846,850,042 |
| **Savings for Pre-Employment Card Beneficiaries** | |
| - Training Fees | 5,929,700,000,000 |
| - Incentive Fund | 14,231,280,000,000 |
| - Survey Completion Incentive Fund | 889,455,000,000 |
| **Total Benefits** | 21,050,435,000,000 |
| **B/C Ratio (Benefit-Cost)** | 1.31 |

Of the cost-benefit analysis, there obtained the total benefit ratio of 1.31, meaning that every 1 rupiah spent for the program, 1.31 benefit was gained. This result implied that the development of used cooking oil into biofuel program was feasible to run. Table 2 presents the number of small-scale industries expected to form by calculating the previous cost analysis. Java Island was the region with the largest small-scale industries which can be formed in Indonesia, while the Maluku and Papua regions were the smallest. It was assumed that each small-scale industries formed received assistance from a processing reactor which has been calculated as part of the investment cost.

**Table 3**. Estimated Number of Small-Scale Industries

| Component | Total |
|---|---|
| Sumatra region | 57.153 |
| Java Region | 131.124 |
| Regional Bali and Nusa Tenggara | 10.575 |
| Kalimantan Region | 14.546 |
| Sulawesi region | 13.717 |
| Maluku and Papua Regions | 6.978 |
| Total | 234.093 |

The cost-benefit analysis in this research was not only done to all regions in general, but also in particular. It aimed at getting the potential provinces to further advance the program through the cost-benefit ratio. For more, the findings indicated six non-potential potential due to the BC ratio < 1, namely North Sumatra (0.74), Lampung (0.81), West Java (0.90), Central Java (0.70), East Java (0.61) and West Papua (0.90). the distribution of which is presented in the form of regional mapping through Figure 3.

Unfortunately, provinces with the biggest production of used cooking oil were not obviously categorized as potential to operate this program in order of relatively higher expenses cost than the benefit. It can be a suggestion for various parties in designing the future programs, namely to consider the cost of raw materials processing in making biofuel from used cooking oil which generally have 60% of the total costs.


**Figure 3.** The Distribution of Potential Provinces for the Development of Programs in terms of the Cost-Benefit Analysis

## CONCLUSION

The mapping of used cooking oil productivity in each province of Indonesia was done to determine the feasibility of the program of used cooking oil processing as a raw material of biofuel. Within this research, the assessment of this program was started from gorming small-scale industries in each potential province of Indonesia. Regarding the results of cost-benefit analysis, it can be concluded that nationally, the program benefits 1.31 times higher than the cost spent, and the formation of 234,093 small-scale industries can give additional values to society economy even to the lowest unit or level.

The mapping of potential regions using the cost-benefit analysis also becomes a solution to see the distribution of potential regions. The government may use this mapping to make related policies, not to mention all the benefits of the program will be able to run with support from the government through a long-term program financing scheme. This program is considered to be more targeted because it is labor-intensive and at the same time answers the government's commitment to reduce carbon emissions from burning fossil fuels.

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**APPENDIX**

| No | Province | Potential (benefit > cost) | Total Benefit (Rp) | Total Cost (Rp) |
|---|---|---|---|---|
| 1 | Aceh | Yes | 481.735.000.000 | 302.421.248.342 |
| 2 | North Sumatra | No | 719.230.000.000 | 976.169.075.698 |
| 3 | West Sumatra | Yes | 548.830.000.000 | 372.986.559.639 |
| 4 | Riau | Yes | 567.290.000.000 | 496.514.598.933 |
| 5 | Riau islands | Yes | 457.240.000.000 | 145.514.334.959 |
| 6 | Jambi | Yes | 430.615.000.000 | 262.191.342.387 |
| 7 | South Sumatra | Yes | 545.990.000.000 | 517.307.721.001 |
| 8 | Bangka Belitung Islands | Yes | 408.605.000.000 | 79.474.668.648 |
| 9 | Bengkulu | Yes | 398.310.000.000 | 127.256.849.651 |
| 10 | Lampung | No | 521.495.000.000 | 640.631.638.647 |
| 11 | DKI Jakarta | Yes | 1.731.690.000.000 | 630.186.190.301 |
| 12 | West Java | No | 2.487.485.000.000 | 2.751.316.728.722 |
| 13 | Banten | Yes | 860.875.000.000 | 808.701.447.770 |
| 14 | Central Java | No | 1.502.360.000.000 | 2.159.234.819.541 |
| 15 | In Yogyakarta | Yes | 532.500.000.000 | 199.772.160.235 |
| 16 | East Java | No | 1.487.805.000.000 | 2.445.367.024.672 |
| 17 | Bali | Yes | 542.440.000.000 | 227.125.706.145 |
| 18 | West Nusa Tenggara | Yes | 447.655.000.000 | 287.530.772.832 |
| 19 | East Nusa Tenggara | Yes | 422.805.000.000 | 210.769.925.121 |
| 20 | West Kalimantan | Yes | 468.955.000.000 | 281.211.193.690 |
| 21 | Central Kalimantan | Yes | 430.615.000.000 | 174.381.171.355 |
| 22 | South Kalimantan | Yes | 481.735.000.000 | 266.161.153.699 |
| 23 | East Kalimantan | Yes | 574.035.000.000 | 237.042.548.375 |
| 24 | North Kalimantan | Yes | 233.235.000.000 | 38.978.511.295 |
| 25 | North Sulawesi | Yes | 412.865.000.000 | 137.122.174.346 |
| 26 | Gorontalo | Yes | 327.310.000.000 | 77.265.644.297 |
| 27 | Central Sulawesi | Yes | 421.385.000.000 | 133.614.196.240 |
| 28 | South Sulawesi | Yes | 640.065.000.000 | 412.480.811.831 |
| 29 | West Sulawesi | Yes | 352.515.000.000 | 62.904.085.281 |
| 30 | Southeast Sulawesi | Yes | 412.155.000.000 | 117.576.180.785 |
| 31 | Maluku | Yes | 340.800.000.000 | 76.608.128.851 |
| 32 | North Maluku | Yes | 303.525.000.000 | 55.595.806.623 |
| 33 | Papuan | Yes | 303.525.000.000 | 64.978.520.814 |
| 34 | West Papua | No | 252.760.000.000 | 281.453.909.314 |
| | Indonesia | | 2s1.050.435.000.000 | 16.057.846.850.042 |