Economic Feasibility Analysis in Developing 5G Infrastructure and Locations in Indonesia

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***Abstract* – Indonesia is preparing advanced telecommunication services, 5G technology, to provide the best service for the internet users. The objective of the research is to find feasible regions in developing 5G technology in Indonesia. The regional selection was carried out by combining Analytical Hierarchy Process (AHP) and Composite Performance Index (CPI). Further, the economic feasibility of the selected locations was evaluated using NPV, IRR and PBP technique. The result found that the potential cities to develop the 5G technology in Indonesia were Jakarta, Surabaya, and Bandung. Economic feasibility evaluations showed that Jakarta and Bandung were the most feasible cities for the first 5G technology development in the future.**

***Keywords*– Analytic hierarchy process, Composite performance index, Feasibility, Telecommunication, 5G technology.**

1. Introduction

The rapid development of cellular telecommunication technology in Indonesia is proof by the use of smartphones as a necessity for the community. The history of mobile telecommunication technology has evolved starting from 1G and followed by the next 2G, 3G, 4G and 5G technologies. The term G or Generation means the development of technological innovation in human life. Currently, cellular telecommunications services have entered the era of 4G (four-generation) internet technology. The growth of internet users in Indonesia is growing very fast, it was recorded that the growth of active internet users in 2018 was 64.8% of the total population or increase up to 10% compared to the previous year. The largest users were on the Java island (55%), then followed by Sumatra (21%), Sulawesi- Maluku-Papua areas (10%), Kalimantan (9%), and Bali and Nusa Tenggara (5%) [1].

It differs from 4G, 5th generation (5G) technology is so superior in speed, able to complement, fill gaps, and improve current 4G technology. Later, 5G technology will be integrated into smartphone technology, big data, internet of things (IoT), cloud computing and supporting digital transformation in various socio-economic sectors including health, smart cars, smart homes, automation industry, finance and others. This technology is supported by the advantages of low latency, real-time communication, and more efficient battery usage [2].

Indonesia also joins another country to adopt this technology and implement it in recently. The various conditions above require the readiness of the Indonesian government and the telecommunications industry in planning the provision of 5G cellular technology services. Several things that have to be considered are developing the planning agenda of this program which include network testing, frequency spectrum slots, infrastructure development, and potential market [3].

For those reasons, as the pilot project of this technology, government and industry have to decide which area to be implemented first. Therefore, the selection of infrastructure development areas is the subject of this research. The importance of selecting the area of implementing 5G technology is based on demographics, high investment costs for equipment, the availability of existing infrastructure networks, the behavior of community needs in using

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telecommunications technology services, and several other factors [4]. These aspects are regulated in government regulations regarding technical guidelines for the location of telecommunications towers which have several criteria based on priority order as follows: population density, cost, distance, and access.

The intense competition, especially the tariff war among telecommunication industry in Indonesia, required to provide affordable technology services with the best quality to customers. This is a challenge for the telecommunications industry because customer expectations are inversely proportional to the increasingly expensive investment in the procurement of telecommunications technology equipment [5]. When business competition is getting tighter, effective management and strategic decision making are required. Therefore, the determination of locations and the feasibility study of the 5G technology implementation are very important to achieve an efficient and competitive price. These requirements have to fulfill to develop an effective and efficient result and the technology which is able to provide the best service for the consumer. By collaborating the several factors above, it will be easier for business people, especially the telecommunications industry, to get the right area as well so that they get benefits and a good experience for customers.

The objective of the research is to determine the specific location of 5G technology implementation in Indonesia and provides the economic feasibility assessment. This research provides a potential location to develop 5G technology based on expert assessment, quantitative measurement and economic feasibility study. This paper is organized as follows: in these sections the research background and research objective are described. The following sections are literature review, methods, result and discussion and conclusions. The framework and supporting theory are described in the literature review. The research stages, framework and the tool analysis are presented at the methods. The result of the analysis and the interpretation of the result is provided at the result and discussion. Finally, the conclusion and recommendation are provided with the general result to answer the research objective.

2. Literature Review

5G Technology

By 2025 it is estimated that 25 billion devices will be connected to 5G technology [6]. The history of telecommunication technology began with the first generation (1G) technology to bring consumers the first mobile phones. Service phones are expensive, and basic analog networks offer voice-only service with limited coverage and capacity. The second-generation (2G) technology uses a digital network, which supports voice and SMS with a wider range. The third-generation (3G) technology supports voice, data, and cellular access to the internet (email and video). At this time smartphones were introduced, and people started using cell phones as computers for business and entertainment, as well as the increasing demand for data services. The fourth-generation (4G) technology offers increased speed, and mobile broadband can support streaming music and video, mobile applications, and online games. Telecommunication operators offer unlimited data plans and mobile devices that can be used as hotspots to connect from other devices to the network, thereby increasing demand for cellular data. Then, the fifth-generation (5G) technology which uses new technology to provide faster speeds, greater capacity, and improved services. The 5G network is expected to meet the growing demand for data from consumers, and to support new services. 5G is also designed to meet the growing demand for data from industrial users, and to support the growing use of mobile communication technology in various industries (plant management systems, public safety applications, and new medical technologies) [3].

The targets obtained in 5G technology planning, in general, are high data rates (1-10 Gbps), latency below 1 ms, cost and energy-efficient, having a capacity of 1000 times than the current capacity, wide coverage using heterogeneous networks, and stable connectivity [7]. 5G technology is very suitable for the development and changes in the industry today, especially industry 4.0. Industry generation 4.0 requires communication technology that has to meet specific industry needs with network infrastructure, time, heterogeneity, safety and security. Several requirements such as industry-specific cycle times and production processes underlie the utilization of this technology. Typically, the utility and food industries are less critical and require a cycle time of around 100 ms. Automotive and heavy equipment production requires a typical cycle time of 10 ms. The highest demand is determined by motion control applications that require a latency of less than 1 ms [8].

Besides, industrial developments that will be based on 5G technology will be closely related to creative applications so that they can encourage the utilization of technology. Inseparable from technological developments, this push can be a necessity, for example, in this case, the GoJek phenomenon. GoJek is a transportation startup service in Indonesia which is a social innovation by applying supply chain management science, where the creation of content or applications (innovation) is based on desire, so that things can run more efficiently and easier [9].

Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Process (AHP) was developed by Thomas Lorie Saaty to find a priority order of various alternatives in problem-solving. In the routine of human life, several alternative options are always encountered in solving a problem [10]. It is also necessary to determine priorities and test the consistency of the choices that have been taken or decided. In a very complex problem situation, decision making is not only influenced by one factor but also by various types of factors.

In AHP, policy priority setting is done by rationally capturing people's perceptions, then converting intangible factors into ordinary rules, so that they can be compared. In this study, the selection of criteria used the AHP method with the following stages [11].

a. Identifying problems and determining the expected solution. This identification is carried out by studying references and discussing with experts who understand the problems so that concepts that are relevant to the problems to be studied will be obtained.
b. The next stage is the preparation of a hierarchical structure by determining objectives and criteria. Perform pairwise comparisons, describing the relative influence of each element on each of the objectives or criteria above it. The pairwise comparison technique used in AHP is based on "judgments" or the opinions of respondents or experts who are considered to be "key persons" through primary data collection or questionnaires. Before the pairwise comparisons, the value was determined to the results of the criteria comparison questionnaire by several experts. The formula for determining the geometric mean is found in Equation 1.

$$MG = \sqrt[n]{\sum_{i=1}^{n} xi} \qquad (1)$$

MG = Geometric Mean
xi = Alternative to-
n = Number of data

c. Normalize data by dividing each paired matrix element value by the total value in each column.
d. Calculating the eigenvector value and testing the level of consistency, and if inconsistent results are obtained. It is done by repeating the data collection process. This eigenvector value is the maximum eigenvector value obtained through Matlab or manual calculations. Besides, we also calculate the weight of each pairwise comparison matrix.
e. Hierarchy consistency testing is conducted, if the value obtained is more than 10%, then the data judgment has to be corrected. Vice versa, if the consistency ratio (CR) is less than 0.1 (CR ≤ 0.1), then the calculation results can be concluded that it is correct. The ratio consistency formula can be seen in Equation 2.

$$CR = \frac{CI}{RI} \qquad (2)$$

CR = Consistency Ratio
CI = Consistency Index
RI = Index Random Consistency

$$CI = \frac{(\lambda_{max} - n)}{n - 1}$$

λmax = The maximum eigenvalues of the pairwise comparison matrix
n = Number of elements

Index random consistency (RI) [12].

Number of Criteria	RI Value	Number of Criteria	RI Value
1	0.00	9	1.45
2	0.00	10	1.49
3	0.58	11	1.51
4	0.90	12	1.48
5	1.12	13	1.56
6	1.24	14	1.57
7	1.32	15	1.59
8	1.41		

Composite Performance Index (CPI)

The Composite Performance Index (CPI) is a composite index that can be used to determine the assessment or ranking of various alternatives (i) based on several criteria (j). The composite performance index method is also a model for calculating the performance index-based decision making and can be used to provide an assessment of various criteria [13].

This method is quite easy to implement manually or in combination with other methods so that one will get decision results from various criteria and good alternatives [14]. Besides, the CPI method developed for sustainability can be useful for assessing industrial performance and identifying socio-economic environmental problems [15].

The following is the calculation procedure using the CPI method [16]:

a. Identifying the criteria for positive trends (the higher the value the better), negative trends (the lower the value the better), and categorizing the data types.
b. In criteria categorized as a trend (+), it is transformed to one hundred for the minimum value for each criterion, while the other values are transformed proportionally higher. The calculation of trend (+) can be seen in Equation 3.

$$\text{Trend } (+) = \frac{\text{N Value}}{\text{Min.value}} \times 100 \qquad (3)$$

c. The criteria categorized as a trend (-) are transformed to one hundred for the minimum value for each criterion, while the other values are transformed proportionally lower. The calculation of trend (-) can be seen in Equation 4.

$$\text{Trend } (-) = \frac{\text{Min.value}}{\text{N value}} \times 100 \qquad (4)$$

d. The calculation of creative value is the sum of the multiplication of the criterion value with the criterion weight and the ranking of the total alternative value.

3. Research Method

In implementing new technology, problems in planning are often faced, especially in deciding which area to be implemented. Indonesia, which is an archipelagic country with large cities, is a challenge for the telecommunications industry. This research composes a scientific framework for the implementation of the 5G technology to provide an effective and efficient business. The research framework is given in Figure 1.

To provide a detailed phase of the research framework above, the research stages are presented in Figure 2.

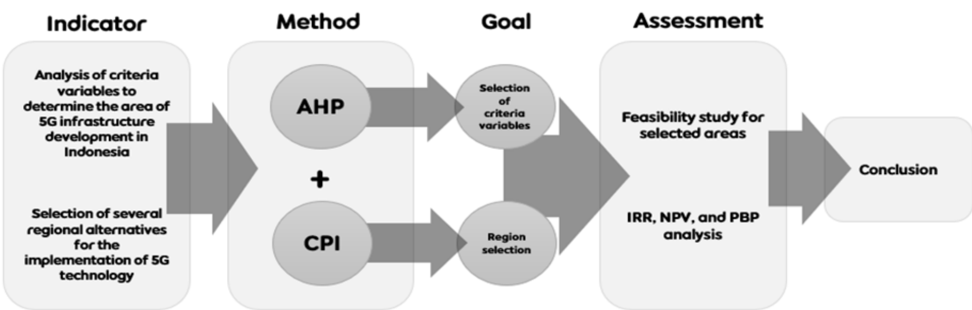

Figure 1. Research framework

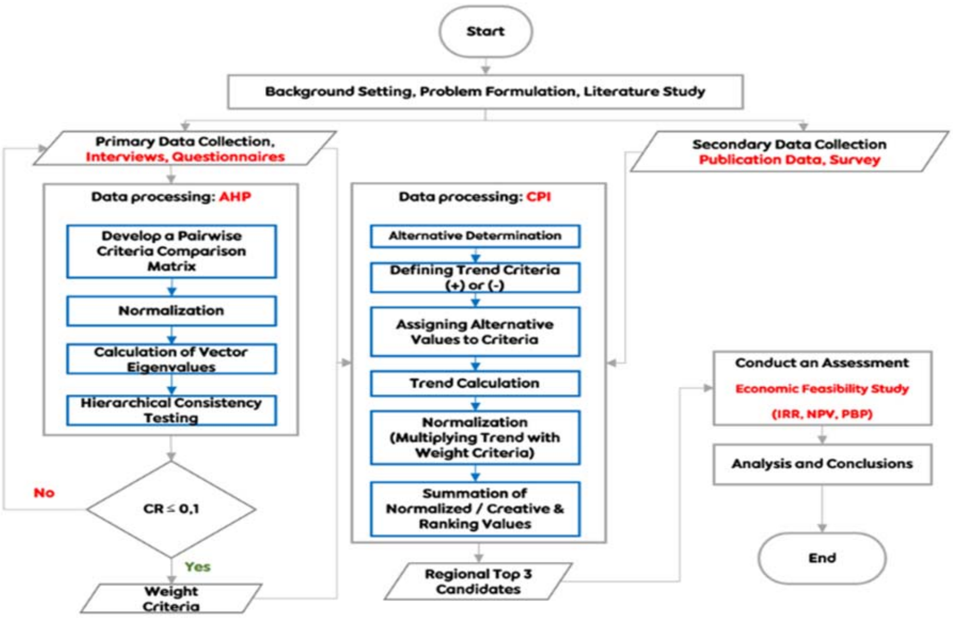

Figure 2. Research stage

The research stages are divided into 3 parts, namely data collection, data analysis using Analytical Hierarchy Process (AHP) and Composite Performance Index (CPI) to determine a location to develop a 5G technology and economic-feasibility analysis to provide detail information of each location. The detail of each stag is described as follows:

a. Data Collection Stage

Data collection in this study consisted of primary and secondary data. Primary data were obtained through questionnaires and in-depth interviews with expert respondents who could provide accurate information [17]. Interviews and questionnaires were conducted to Subject Matter Experts (SME) in telecommunications and 5G technology expert. The details of the subject matter experts (SME) are described in Table 1.

Table 1. Subject matter experts

No	Professional background	Amount
1	Tower Provider	1
2	Seluler Operators	7
3	Academics	1
4	Government	1
	Total	**10**

b. Determine 5G technology locations using AHP and CPI
In the AHP method, policy priority setting is done by capturing people's perceptions rationally, then converting intangible (unmeasured) factors into ordinary rules, so they can be compared. In selecting 5G technology locations, the AHP method is used to determine the weight of the criteria. The objectives and required criteria can be described in the AHP hierarchy in Figure 3.
The criteria weight results obtained by the AHP method will be used for the calculation process and the trending value multiplier for each alternative specified in the CPI method. The alternative areas in question include Jakarta, Bandung, Semarang, Yogyakarta, Surabaya, Denpasar, Medan and Makassar. The final results of the AHP and CPI methods will be obtained by ranking of the alternative areas.

c. Economic-feasibility analysis
The main objective of investing is to obtain a high profit or return. A project or business feasibility study is an activity to evaluate, analyze, and assess whether or not a business project is feasible to run [18]. A feasibility study is needed before the implementation of a business, this is used as a consideration in making decisions. Several quantitative methods are used to determine investment eligibility standards:

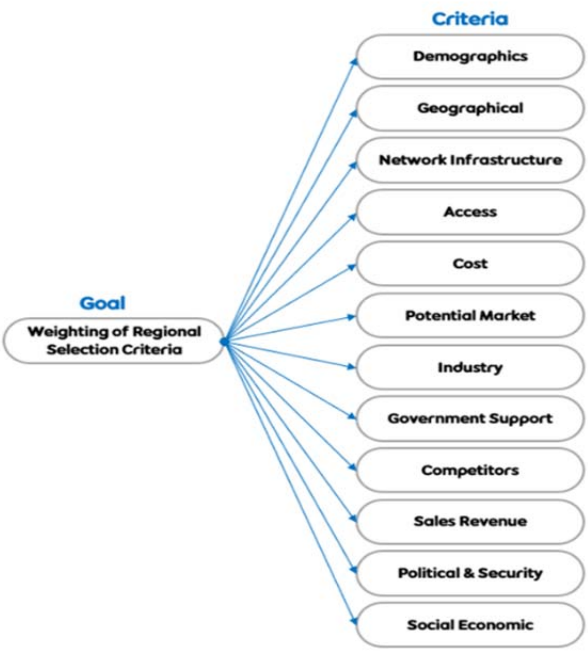

Figure 3. Structure hierarchy AHP

Net Present Value (NPV), the net profit is calculated from the difference between the present value of the investment and the present value of the expected net cash flow receipts from the project or investment in the future or a certain period [19]. The NPV formula can be seen in Equation 5.

$$NPV = (-CF_0) + \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t} \quad (5)$$

CF0 = Initial investment year 0 (initial cost incurred to invest in the project)
CFt = Cash flow generated during the specified period (year t)
r = Discount rate
t = Year t
n = The final period of the expected cash flow

Internal Rate Return (IRR), the investment rate is the interest rate at which all net cash flow is multiplied by the discounted factor or present value, which equals the cost of investment. The IRR value can be calculated by finding the interest rate (discounted rate) which will produce NVP equal to zero [20]. The IRR formula can be seen in Equation 6.

$$IRR = i_1 + \frac{NPV_1}{(NPV_1 - NPV_2)}(i_2 - i_1) \quad (6)$$

i_1 = The first interest rate that will produce a positive NPV
i_2 = The second interest rate that will result in a negative NPV
NPV1 = Net Present Value (NPV) (+)
NPV2 = Net Present Value (NPV) (-)

Pay Back Period (PBP), the period required to recoup the investment issued (initial cash investment) using cash flow or a period that shows the length of return on capital invested in the project implementation [21].

4. Result and Discussion

Analysis of the criteria to determine the locations of 5G implementation

There are huge criteria to determine an effective location for the implementations of the 5G technology. An AHP is a powerful technique to determine the criteria based on expert assessment. AHP develop a hierarchy to analyze the criteria and provide the weighted value. As mentioned in the method, there are 12 criteria to consider in determining the locations of 5G technology development in Indonesia.

Through interviews and questionnaires, criteria data are compared and evaluated by experts, so that accurate primary data is obtained according to the topic under study. Primary data can be presented in Table 2.

Table 2. Primary data for processing the AHP method

No	Left side criteria	Right side criteria	Primary data SME to-										Geomean
			1	2	3	4	5	6	7	8	9	10	
1	Demographics	Geographical	7,00	8,00	3,00	7,00	7,00	9,00	3,00	3,00	6,00	4,00	5,25
2	Demographics	Network Infrastructure	0,11	0,50	0,14	0,14	0,14	0,11	0,14	0,11	0,33	2,00	0,21
3	Demographics	Access	0,33	0,50	0,33	5,00	5,00	7,00	0,20	0,20	3,00	3,00	1,13
4	Demographics	Cost	0,11	0,13	0,20	0,20	5,00	7,00	0,20	0,14	2,00	0,33	0,45
5	Demographics	Potential Market	0,11	0,13	0,14	0,14	0,33	0,20	0,11	0,11	0,50	0,20	0,17
6	Demographics	Industry	0,50	0,20	0,14	0,17	3,00	0,50	0,11	0,13	0,50	6,00	0,41
7	Demographics	Government Support	3,00	0,11	0,33	0,14	0,20	0,20	0,11	0,13	0,33	0,17	0,23
8	Demographics	Competitors	0,33	0,14	0,20	0,33	0,20	3,00	5,00	0,50	4,00	7,00	0,82
9	Demographics	Sales revenue	0,11	0,14	0,14	0,11	0,50	0,13	0,14	0,13	0,13	3,00	0,20
10	Demographics	Political & Security	2,00	6,00	3,00	3,00	0,50	4,00	0,14	0,20	0,14	2,00	1,06
11	Demographics	Social Economic	0,20	0,20	0,33	0,14	0,50	2,00	0,11	6,00	0,33	2,00	0,49
12	Geographical	Network Infrastructure	0,14	2,00	0,14	0,14	0,14	0,11	0,14	0,33	2,00	0,17	0,26
13	Geographical	Access	0,14	0,14	0,33	0,50	0,50	0,11	0,14	0,33	4,00	0,33	0,32
14	Geographical	Cost	0,11	0,14	0,20	0,14	0,50	0,11	0,20	0,20	2,00	3,00	0,30
15	Geographical	Potential Market	0,11	0,33	0,14	0,14	0,14	0,11	0,20	0,50	0,25	0,33	0,20
16	Geographical	Industry	0,50	0,33	0,14	0,17	0,50	0,14	0,14	0,17	0,14	5,00	0,29
17	Geographical	Government Support	0,33	0,11	0,33	0,14	3,00	0,25	4,00	0,13	0,25	0,17	0,35
18	Geographical	Competitors	0,33	0,33	0,20	5,00	0,25	0,17	3,00	3,00	0,20	4,00	0,71
19	Geographical	Sales revenue	0,11	0,25	0,14	0,11	0,25	0,13	0,33	0,20	0,13	0,33	0,18
20	Geographical	Political & Security	0,33	0,25	0,33	3,00	0,25	0,13	0,11	4,00	0,14	0,20	0,36
21	Geographical	Social Economic	0,20	0,25	0,33	0,14	0,50	0,13	0,25	3,00	0,14	0,14	0,27
22	Network Infrastructure	Access	5,00	4,00	5,00	9,00	5,00	7,00	3,00	3,00	6,00	7,00	5,10
23	Network Infrastructure	Cost	0,33	2,00	0,20	2,00	5,00	0,50	7,00	0,25	2,00	7,00	1,32
24	Network Infrastructure	Potential Market	0,20	3,00	0,14	0,33	5,00	0,17	5,00	0,33	0,20	7,00	0,75
25	Network Infrastructure	Industry	3,00	3,00	3,00	0,33	5,00	0,17	0,14	0,33	0,17	7,00	0,92
26	Network Infrastructure	Government Support	3,00	0,11	5,00	0,14	0,50	2,00	0,14	0,20	0,17	7,00	0,62
27	Network Infrastructure	Competitors	3,00	2,00	0,33	7,00	3,00	0,17	7,00	3,00	0,50	7,00	1,87
28	Network Infrastructure	Sales revenue	0,14	3,00	0,14	0,11	3,00	0,13	7,00	0,33	0,17	7,00	0,61
29	Network Infrastructure	Political & Security	3,00	6,00	5,00	7,00	0,50	2,00	0,33	5,00	0,14	7,00	2,01
30	Network Infrastructure	Social Economic	0,33	3,00	5,00	0,14	3,00	2,00	0,50	4,00	0,17	7,00	1,26
31	Access	Cost	0,11	2,00	0,20	0,14	0,33	0,13	0,14	0,33	0,20	7,00	0,33
32	Access	Potential Market	0,11	0,11	0,11	0,14	0,33	0,11	0,14	0,20	0,17	7,00	0,22
33	Access	Industry	3,00	2,00	0,20	0,14	3,00	0,11	0,14	0,17	0,17	7,00	0,52
34	Access	Government Support	3,00	0,11	0,33	0,14	0,33	0,17	0,11	0,14	0,17	7,00	0,33
35	Access	Competitors	3,00	3,00	0,33	3,00	0,33	0,13	5,00	3,00	0,17	7,00	1,21
36	Access	Sales revenue	0,14	0,33	0,14	0,11	0,20	0,11	3,00	0,20	0,14	7,00	0,32
37	Access	Political & Security	3,00	3,00	0,33	5,00	0,50	0,17	0,33	0,33	0,17	7,00	0,83
38	Access	Social Economic	0,20	0,20	0,33	0,14	0,50	0,17	0,20	5,00	0,14	7,00	0,42
39	Cost	Potential Market	3,00	0,50	0,14	0,25	0,20	0,11	0,20	3,00	0,25	0,33	0,38
40	Cost	Industry	5,00	2,00	0,20	5,00	2,00	2,00	5,00	3,00	0,14	5,00	1,83
41	Cost	Government Support	5,00	0,11	3,00	0,14	0,33	4,00	0,33	0,14	0,20	0,14	0,46
42	Cost	Competitors	5,00	2,00	0,33	7,00	0,33	7,00	0,33	3,00	0,20	3,00	1,42
43	Cost	Sales revenue	0,20	0,20	0,14	0,11	0,20	0,11	3,00	3,00	0,14	0,33	0,30
44	Cost	Political & Security	5,00	3,00	5,00	7,00	0,33	8,00	0,33	0,50	0,20	0,14	1,21
45	Cost	Social Economic	5,00	0,25	7,00	5,00	0,33	8,00	3,00	4,00	0,17	0,17	1,44
46	Potential Market	Industry	3,00	2,00	5,00	9,00	8,00	2,00	5,00	6,00	0,33	5,00	3,42
47	Potential Market	Government Support	5,00	0,11	3,00	0,14	0,50	5,00	3,00	3,00	0,33	0,14	0,87
48	Potential Market	Competitors	5,00	6,00	5,00	7,00	3,00	2,00	7,00	2,00	3,00	4,00	4,00
49	Potential Market	Sales revenue	0,14	0,50	0,14	0,25	0,50	0,20	7,00	0,25	0,25	0,33	0,36
50	Potential Market	Political & Security	5,00	7,00	3,00	7,00	2,00	2,00	0,50	4,00	0,33	0,14	1,76
51	Potential Market	Social Economic	5,00	2,00	7,00	0,25	3,00	2,00	5,00	5,00	0,50	0,14	1,69
52	Industry	Government Support	0,33	0,11	3,00	0,14	0,33	5,00	0,11	0,33	3,00	0,14	0,46
53	Industry	Competitors	3,00	0,25	0,33	4,00	0,33	7,00	9,00	2,00	6,00	0,14	1,43
54	Industry	Sales revenue	0,11	0,25	0,14	0,11	0,17	0,11	5,00	0,25	5,00	0,14	0,31
55	Industry	Political & Security	3,00	7,00	3,00	0,25	0,33	4,00	0,11	0,50	0,50	0,14	0,78
56	Industry	Social Economic	3,00	3,00	3,00	0,14	0,33	4,00	9,00	2,00	4,00	0,14	1,49
57	Government Support	Competitors	3,00	9,00	0,33	9,00	2,00	0,50	9,00	3,00	2,00	7,00	2,81
58	Government Support	Sales revenue	0,11	9,00	0,14	0,25	2,00	0,33	9,00	0,25	0,33	7,00	0,81
59	Government Support	Political & Security	3,00	9,00	3,00	7,00	0,50	9,00	6,00	6,00	0,50	7,00	3,55
60	Government Support	Social Economic	0,33	9,00	0,33	0,25	4,00	7,00	0,33	5,00	0,25	7,00	1,35
61	Competitors	Sales revenue	0,11	0,17	0,14	0,11	0,14	0,11	2,00	0,20	0,25	0,33	0,21
62	Competitors	Political & Security	3,00	5,00	3,00	0,33	0,50	0,20	0,11	0,33	0,50	0,20	0,59
63	Competitors	Social Economic	3,00	3,00	3,00	0,14	7,00	0,50	0,14	0,50	0,20	0,14	0,70
64	Sales revenue	Political & Security	9,00	6,00	7,00	9,00	0,50	3,00	0,14	4,00	7,00	0,14	2,22
65	Sales revenue	Social Economic	9,00	6,00	7,00	7,00	8,00	6,00	0,25	3,00	6,00	0,17	3,15
66	Political & Security	Social Economic	0,33	0,20	0,33	0,14	4,00	0,50	6,00	2,00	0,17	0,14	0,53

From the data that has been obtained above, it is compiled in a pairwise comparison matrix whose results were shown in Table 3. The next step is to normalize each value from the pairwise comparison matrix by dividing the total value of each criterion column, the results of which can be seen in Table 4 so that the eigenvector value can be obtained. This eigenvector value will later become the weight input of the criteria which functions as a multiplier in the data processing using the CPI method.

Before stepping into processing with the CPI method, checking the calculation and consistency of the hierarchy follows, done by dividing the value of the consistency index (CI) to the index random consistency (RI).

The consistency index (CI) can be obtained from the calculation below.

$$\mathrm{CI} = \frac{(\lambda_{\max} - \mathrm{n})}{\mathrm{n} - 1} = \frac{(12{,}48 - 12)}{12 - 1} = 0.06$$

While the index random consistency (RI) value was obtained from the Table, which in this research used 12 criteria so that the RI value is 1.48 from the Table.

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}} = \frac{0.06}{1.48} = 0.042$$

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Table 3. Pairwise comparison matrix

Criteria	Demographics	Geographical	Network Infrastructure	Access	Cost	Potential Market	Industry	Government support	Competitors	Sales revenue	Political & Security	Social Economic
Demographics	1	5,2532	0,2128	1,1335	0,4538	0,1725	0,4143	0,2339	0,8175	0,2006	1,0584	0,4929
Geographical	0,1904	1	0,2610	0,3220	0,3007	0,1995	0,2940	0,3500	0,7117	0,1813	0,3564	0,2727
Network Infrastructure	4,6992	3,8308	1	5,1001	1,3222	0,7490	0,9162	0,6165	1,8670	0,6084	2,0050	1,2589
Access	0,8823	3,1052	0,1961	1	0,3347	0,2180	0,5249	0,3321	1,2070	0,3165	0,8336	0,4169
Cost	2,2036	3,3254	0,7563	2,9878	1	0,3780	1,8332	0,4608	1,4171	0,3007	1,2089	1,4421
Potential Market	5,7971	5,0120	1,3351	4,5881	2,6456	1	3,4154	0,8723	4,0037	0,3606	1,7568	1,6877
Industry	2,4140	3,4017	1,0915	1,9052	0,5455	0,2928	1	0,4595	1,4310	0,3064	0,7800	1,4871
Government support	4,2755	2,8574	1,6219	3,0109	2,1700	1,1464	2,1761	1	2,8093	0,8123	3,5540	1,3521
Competitors	1,2232	1,4051	0,5356	0,8285	0,7057	0,2498	0,6988	0,3560	1	0,2085	0,5949	0,6983
Sales revenue	4,9854	5,5171	1,6438	3,1598	3,3254	2,7730	3,2638	1,2311	4,7953	1	2,2206	3,1469
Political & Security	0,9449	2,8058	0,4987	1,1996	0,8272	0,5692	1,2821	0,2814	1,6808	0,4503	1	0,5319
Social Economic	2,0288	3,6665	0,7943	2,3985	0,6935	0,5925	0,6724	0,7396	1,4321	0,3178	1,8799	1
Total	**30,6443**	**41,1802**	**9,9472**	**27,6340**	**14,3243**	**8,3406**	**16,4912**	**6,9333**	**23,1726**	**5,0633**	**17,2485**	**13,7876**

Table 4. Normalization of the pairwise comparison matrix value

Criteria	Demographics	Geographical	Network Infrastructure	Access	Cost	Potential Market	Industry	Government support	Competitors	Sales revenue	Political & Security	Social Economic	TOTAL
Demographics	0,0326	0,1276	0,0214	0,0410	0,0317	0,0207	0,0251	0,0337	0,0353	0,0396	0,0614	0,0358	0,5058
Geographical	0,0062	0,0243	0,0262	0,0117	0,0210	0,0239	0,0178	0,0505	0,0307	0,0358	0,0207	0,0198	0,2886
Network Infrastructure	0,1533	0,0930	0,1005	0,1846	0,0923	0,0898	0,0556	0,0889	0,0806	0,1202	0,1162	0,0913	1,2663
Access	0,0288	0,0754	0,0197	0,0362	0,0234	0,0261	0,0318	0,0479	0,0521	0,0625	0,0483	0,0302	0,4825
Cost	0,0719	0,0808	0,0760	0,1081	0,0698	0,0453	0,1112	0,0665	0,0612	0,0594	0,0701	0,1046	0,9248
Potential Market	0,1892	0,1217	0,1342	0,1660	0,1847	0,1199	0,2071	0,1258	0,1728	0,0712	0,1019	0,1224	1,7169
Industry	0,0788	0,0826	0,1097	0,0689	0,0381	0,0351	0,0606	0,0663	0,0618	0,0605	0,0452	0,1079	0,8155
Government support	0,1395	0,0694	0,1631	0,1090	0,1515	0,1374	0,1320	0,1442	0,1212	0,1604	0,2060	0,0981	1,6318
Competitors	0,0399	0,0341	0,0538	0,0300	0,0493	0,0299	0,0424	0,0513	0,0432	0,0412	0,0345	0,0506	0,5003
Sales revenue	0,1627	0,1340	0,1652	0,1143	0,2322	0,3325	0,1979	0,1776	0,2069	0,1975	0,1287	0,2282	2,2778
Political & Security	0,0308	0,0681	0,0501	0,0434	0,0577	0,0682	0,0777	0,0406	0,0725	0,0889	0,0580	0,0386	0,6949
Social Economic	0,0662	0,0890	0,0799	0,0868	0,0484	0,0710	0,0408	0,1067	0,0618	0,0628	0,1090	0,0725	0,8949
Total	**1,00**	**1,00**	**1,00**	**1,00**	**1,00**	**1,00**	**1,00**	**1,00**	**1,00**	**1,00**	**1,00**	**1,00**	**12,00**

Table 5. The results of weighting criteria using the AHP

Criteria	Weight	Trend
Demographics	0.0422	Positive
Geographical	0.0240	Negative
Network Infrastructure	0.1055	Positive
Access	0.0402	Positive
Cost	0.0771	Negative
Potential Market	0.1431	Positive
Industry	0.0680	Positive
Government Support	0.1360	Positive
Competitors	0.0417	Negative
Sales Revenue	0.1898	Positive
Political & Security	0.0579	Positive
Social Economic	0.0746	Positive

Based on the above calculations, the CR (consistency ratio) value is ≤ 0.1, so the results of data collection and processing are stated to be consistent. From the calculation of the AHP method above, the results of the weighted criteria are obtained which can be seen in Table 5.

Determine the specific locations using CPI

To support the calculation process using the CPI method, an assessment of alternative data and criteria obtained from primary (questionnaire) and secondary (literature study) data was carried out as described in Table 6.

Following the principles of the CPI method, trending was also carried out against the criteria factors which can be seen in Table 5.

For the criteria attribute that is categorized as a trend (+), it is transformed to one hundred for the minimum value for each criterion, while other values are transformed proportionally higher. On the other hand, criteria categorized as a trend (-) are transformed to one hundred for the minimum value for each criterion, while the other values are transformed proportionally lower. Processing and the results of these calculations can be seen in Table 7. The next step is to multiply the AHP criterion weight by the trending value for each value in Table 7, and results can be seen in Table 8 and Figure 4.

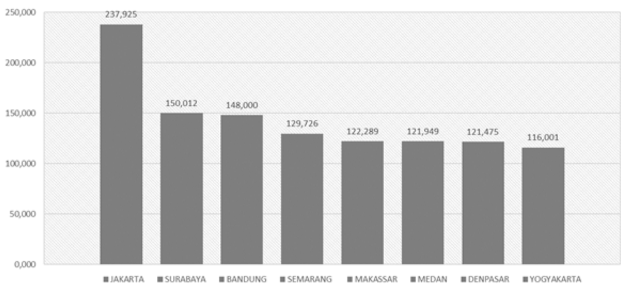

Figure 4. The final value of the alternative area with the CPI method

In Table 8 and Figure 4, we can obtain the ranking order of the final values for regional elections, namely Jakarta, Surabaya, Bandung, Semarang, Medan, Makassar, Denpasar and Yogyakarta. We obtained three major areas that were used as proposals for the development of 5G technology infrastructure, namely Jakarta, Surabaya, and Bandung.

Regional Economic Feasibility Analysis

In a business investment process, it is not enough only to determine the area of the implementation plan, but also an analysis of its economic feasibility. There are differences in the parameters of the economic feasibility analysis of a company with other companies, this is due to the policies of each company due to differences in types of business. Three main factors are the same in analyzing economic feasibility, namely Capital expenditure (CAPEX), Operational expenditure (OPEX), and revenue [22]. In this research, an analysis of economic feasibility was carried out on the three regions that had the highest value in the calculation of the decision support system analysis above. An overview of the economic feasibility analysis planning method can be seen in Figure 5.

Table 6. Primary data and secondary data for processing the CPI method

Region	Demographics	Geographical	Network Infrastructure	Access	Cost	Potential Market	Industry	Government support	Competitors	Sales revenue	Political & Security	Social Economic
JAKARTA	11.100.929,00	2	5	5	4	5	4	4	4	5	3	4
BANDUNG	2.490.386,00	3	5	5	4	4	4	4	4	5	4	4
SEMARANG	1.681.058,00	2	4	4	3	4	4	4	4	4	3	4
YOGYAKARTA	414.919,00	2	3	5	4	5	4	4	4	4	3	4
SURABAYA	2.959.082,00	3	5	5	4	5	4	4	4	4	4	4
DENPASAR	651.201,00	2	3	5	4	5	5	4	4	4	5	3
MEDAN	2.520.416,00	2	3	4	4	4	4	3	4	3	3	4
MAKASSAR	1.484.912,00	2	3	4	4	4	4	4	4	4	3	4

Table 7. The results of the calculation of trending criteria

Region	Demographics	Geographical	Network Infrastructure	Access	Cost	Potential Market	Industry	Government support	Competitors	Sales revenue	Political & Security	Social Economic
JAKARTA	2675,4448	100,0000	166,6667	125,0000	75,0000	125,0000	100,0000	133,3333	100,0000	166,6667	100,0000	133,3333
BANDUNG	600,2102	66,6667	166,6667	125,0000	75,0000	100,0000	100,0000	133,3333	100,0000	166,6667	133,3333	133,3333
SEMARANG	405,1533	100,0000	133,3333	100,0000	100,0000	100,0000	100,0000	133,3333	100,0000	133,3333	100,0000	133,3333
YOGYAKARTA	100,0000	100,0000	100,0000	125,0000	75,0000	125,0000	100,0000	133,3333	100,0000	133,3333	100,0000	133,3333
SURABAYA	713,1710	66,6667	166,6667	125,0000	75,0000	125,0000	100,0000	133,3333	100,0000	133,3333	133,3333	133,3333
DENPASAR	156,9465	100,0000	100,0000	125,0000	75,0000	125,0000	125,0000	133,3333	100,0000	133,3333	166,6667	100,0000
MEDAN	607,4477	100,0000	100,0000	100,0000	75,0000	100,0000	100,0000	100,0000	100,0000	100,0000	100,0000	133,3333
MAKASSAR	357,8800	100,0000	100,0000	100,0000	75,0000	100,0000	100,0000	133,3333	100,0000	133,3333	100,0000	133,3333

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Table 8. The result of multiplying the trending value with the criterion weight value

Region	Demographics	Geographical	Network Infrastructure	Access	Cost	Potential Market	Industry	Government support	Competitors	Sales revenue	Political & Security	Social Economic	Total
JAKARTA	112,7763	2,4047	17,5878	5,0259	5,7800	17,8845	6,7958	18,1312	4,1689	31,6358	5,7906	9,9430	**237,9245**
BANDUNG	25,3003	1,6031	17,5878	5,0259	5,7800	14,3076	6,7958	18,1312	4,1689	31,6358	7,7208	9,9430	**148,0002**
SEMARANG	17,0782	2,4047	14,0702	4,0207	7,7066	14,3076	6,7958	18,1312	4,1689	25,3087	5,7906	9,9430	**129,7262**
YOGYAKARTA	4,2152	2,4047	10,5527	5,0259	5,7800	17,8845	6,7958	18,1312	4,1689	25,3087	5,7906	9,9430	**116,0011**
SURABAYA	30,0618	1,6031	17,5878	5,0259	5,7800	17,8845	6,7958	18,1312	4,1689	25,3087	7,7208	9,9430	**150,0115**
DENPASAR	6,6157	2,4047	10,5527	5,0259	5,7800	17,8845	8,4948	18,1312	4,1689	25,3087	9,6510	7,4573	**121,4752**
MEDAN	25,6054	2,4047	10,5527	4,0207	5,7800	14,3076	6,7958	13,5984	4,1689	18,9815	5,7906	9,9430	**121,9492**
MAKASSAR	15,0855	2,4047	10,5527	4,0207	5,7800	14,3076	6,7958	18,1312	4,1689	25,3087	5,7906	9,9430	**122,2893**

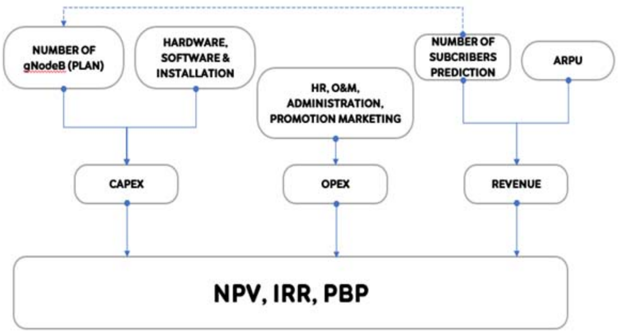

Figure 5. Economic feasibility analysis framework

Several parameter assumptions were also established for this analysis which is represented the telecommunications industry in Indonesia. Investment planning is determined in five years between 2021 and 2025. The frequency spectrum applied to 5G technology varies widely, some of which are 28 GHz, 26 GHz, and 3.5 GHz [23]. Currently, there is no official stipulation from the Indonesian government that regulates the placement of the 5G service frequency, therefore this paper apply 3.5 GHz frequency. It is based on the direction of the Indonesian government to carry out technical tests of 5G technology devices in the 3.5 GHz frequency spectrum, whose ecosystems have been used in several countries that were already implemented 5G services.

The components in the preparation of the CAPEX budget in this study include the procurement of hardware, software, installation commissioning, and procurement of backhaul for the transmission network. The components in the preparation of the OPEX budget for the development of 5G infrastructure include promotion and marketing costs, administrative costs, operational and maintenance costs, and human resource costs. Promotion and marketing costs are set at 2% of the CAPEX value. The administrative fee is set at 1% of the CAPEX value. Operational and maintenance costs are set at 3% of the CAPEX value. Human resource costs are the estimated salaries of personnel assigned to 5G implementation projects in a selected region.

Revenue planning for an investment in the telecommunications industry can be obtained from the average revenue per user (ARPU) value and the prediction of the number of subscribers or users of 5G service users in the selected area [24]. The revenue calculation formula can be calculated using Equation 7.

$$\text{Revenue} = \text{User Prediction} \times \text{ARPU} \quad (7)$$

Determining the budget for implementing 5G technology cannot be separated from the planned number of gNodeB (5G base stations) to be built in the selected area. The calculation of the number of gNodeB is based on the prediction of the number of customers to be served as well as the average population density of an area. The population density of the selected areas can be seen in Table 9.

Table 9. The population density of the selected areas

City	Population density (People/Km^2)
Jakarta	16.718
Surabaya	8.441
Bandung	14.853

Source: Kemendagri RI, 2020

Table 10. The number of gNodeB 2021 – 2025

City	The Number of gNodeB Year to-				
	2021	2022	2023	2024	2025
Jakarta	8	24	44	41	24
Surabaya	4	13	23	22	12
Bandung	2	6	11	10	6

$$L = 1.95 \times 2.6 \times d^2 \quad (8)$$

d = cell radius

$$L = 1.95 \times 2.6 \times 0.5^2 = 1.2675 \text{ Km2}$$

The coverage area of the three sectors of 5G technology in the 3.5 GHz frequency spectrum is assumed to be able to serve areas with the calculation of Equation 8 [25].

It is estimated that the number of users of 5G technology services is around 40% of the population density per km^2. So, the calculation of the number of gNodeB can be obtained with Equation 9 and the results can be seen in Table 10.

$$\text{Num. gNodeB} = \frac{\text{Subscribers prediction}}{\text{coverage area}} \quad (9)$$

From the results of data processing, economic calculations will be obtained for each region as presented in Table 11, Table 12 and Table 13. By using the economic investment calculation data, the NPV, IRR and PBP values are obtained, and they are presented in Table 14.

Based on the economic feasibility analysis of the three selected areas, the results show that Jakarta and Bandung are the most economically viable cities for the construction of the first 5G infrastructure in Indonesia.

Table 11. Economic investment calculations for the Jakarta area 2021 - 2025

NO	KOMPONEN	2021	2022	2023	2024	2025
1	CAPEX	IDR 5.314.988.152	IDR 15.565.322.445	IDR 28.473.150.814	IDR 26.574.940.760	IDR 15.185.680.434
2	OPEX	IDR 1.380.826.666	IDR 2.257.373.845	IDR 3.509.033.977	IDR 4.446.018.215	IDR 4.528.182.642
3	BANK INTEREST (7.5% * CAPEX)	IDR -	IDR 1.167.399.183	IDR 2.135.486.311	IDR 1.993.120.557	IDR 1.138.926.033
4	DEPRECIATION	IDR -	IDR 1.257.917.942	IDR 1.850.870.279	IDR 1.307.293.076	IDR 626.971.514
5	TOTAL COST (2+3+4)	IDR 1.380.826.666	IDR 4.682.690.970	IDR 7.495.390.567	IDR 7.746.431.847	IDR 6.294.080.189
6	REVENUE	IDR 5.512.500.000	IDR 21.223.125.000	IDR 49.160.475.000	IDR 74.118.870.000	IDR 87.163.791.120
7	EBIT-Earning before interest tax (6-5)	IDR 4.131.673.334	IDR 16.540.434.030	IDR 41.665.084.433	IDR 66.372.438.153	IDR 80.869.710.931
8	TAX (20% * EBIT)	IDR -	IDR 3.308.086.806	IDR 8.333.016.887	IDR 13.274.487.631	IDR 16.173.942.186
9	EAT -Earning after tax (7-8)	IDR 4.131.673.334	IDR 13.232.347.224	IDR 33.332.067.547	IDR 53.097.950.522	IDR 64.695.768.745
10	PROCEEDS (9-1)	-IDR 1.183.314.818	-IDR 2.332.975.221	IDR 4.858.916.732	IDR 26.523.009.762	IDR 49.510.088.310

Table 12. Economic investment calculations for the Surabaya area 2021 – 2025

NO	KOMPONEN	2021	2022	2023	2024	2025
1	CAPEX	IDR 1.357.655.726	IDR 8.463.495.486	IDR 7.273.155.673	IDR 6.788.278.628	IDR 3.879.016.359
2	OPEX	IDR 1.146.198.734	IDR 1.524.431.795	IDR 1.764.046.318	IDR 1.998.654.202	IDR 2.054.197.895
3	BANK INTEREST (7.5% * CAPEX)	IDR -	IDR 634.762.161	IDR 545.486.675	IDR 509.120.897	IDR 290.926.227
4	DEPRECIATION	IDR -	IDR 676.136.036	IDR 467.362.069	IDR 330.103.738	IDR 158.316.176
5	TOTAL COST (2+3+4)	IDR 1.146.198.734	IDR 2.835.329.993	IDR 2.776.895.063	IDR 2.837.878.837	IDR 2.503.440.297
6	REVENUE	IDR 1.236.676.032	IDR 4.761.202.722	IDR 11.028.676.852	IDR 16.627.851.253	IDR 19.554.353.074
7	EBIT-Earning before interest tax (6-5)	IDR 90.477.298	IDR 1.925.872.730	IDR 8.251.781.788	IDR 13.789.972.416	IDR 17.050.912.776
8	TAX (20% * EBIT)	IDR -	IDR 385.174.546	IDR 1.650.356.358	IDR 2.757.994.483	IDR 3.410.182.555
9	EAT -Earning after tax (7-8)	IDR 90.477.298	IDR 1.540.698.184	IDR 6.601.425.431	IDR 11.031.977.933	IDR 13.640.730.221
10	PROCEEDS (9-1)	-IDR 1.267.178.428	-IDR 6.922.797.302	-IDR 671.730.242	IDR 4.243.699.305	IDR 9.761.713.862

Table 13. Economic investment calculations for the Bandung area 2021 – 2025

NO	KOMPONEN	2021	2022	2023	2024	2025
1	CAPEX	IDR 2.852.461.180	IDR 8.353.636.314	IDR 15.281.042.038	IDR 14.262.305.902	IDR 8.149.889.087
2	OPEX	IDR 1.200.465.106	IDR 1.557.411.524	IDR 2.088.310.167	IDR 2.426.600.209	IDR 2.554.559.093
3	BANK INTEREST (7.5% * CAPEX)	IDR -	IDR 626.522.724	IDR 1.146.078.153	IDR 1.069.672.943	IDR 611.241.682
4	DEPRECIATION	IDR -	IDR 665.380.642	IDR 979.025.112	IDR 691.497.813	IDR 331.639.048
5	TOTAL COST (2+3+4)	IDR 1.200.465.106	IDR 2.849.314.889	IDR 4.213.413.432	IDR 4.187.770.965	IDR 3.497.439.822
6	REVENUE	IDR 1.472.231.250	IDR 5.668.090.313	IDR 13.129.358.288	IDR 19.795.032.495	IDR 23.278.958.214
7	EBIT-Earning before interest tax (6-5)	IDR 271.766.144	IDR 2.818.775.423	IDR 8.915.944.856	IDR 15.607.261.530	IDR 19.781.518.392
8	TAX (20% * EBIT)	IDR -	IDR 563.755.085	IDR 1.783.188.971	IDR 3.121.452.306	IDR 3.956.303.678
9	EAT -Earning after tax (7-8)	IDR 271.766.144	IDR 2.255.020.339	IDR 7.132.755.885	IDR 12.485.809.224	IDR 15.825.214.713
10	PROCEEDS (9-1)	-IDR 2.580.695.037	-IDR 6.098.615.975	-IDR 8.148.286.153	-IDR 1.776.496.677	IDR 7.675.325.627

Table 14. The results of the economic feasibility analysis of the NPV, IRR, PBP

CITY	ECONOMIC FEASIBILITY ANALYSIS			ASSESMENT
	NPV	IRR	PBP	
JAKARTA	IDR 58.268.474.080,09	209,8%	2 Years 11 Months	FEASIBLE
SURABAYA	-IDR 10.982.050.591,35	-31,1%	5 Years 4 Months	NOT FEASIBLE
BANDUNG	IDR 2.290.860.089,50	18,0%	3 Years 10 Months	FEASIBLE

5. Conclusion

This research provides a complete analysis to determine feasible locations to develop an efficient 5G technology in Indonesia. There are 12 criteria to consider in determining the locations. Expert and quantitative data are analyzed using AHP and CPI technique and find three cities to consider in developing 5G technology, namely Jakarta, Bandung, and Surabaya. Further, based on a feasibility study, Jakarta and Bandung are the most viable cities to develop the 5G technology in the future based on specific criteria. Jakarta has NPV value IDR. 58.268.474.080,09; IRR value is 209.8% and the payback period is 2 years 11 months while Bandung has the NPV value is IDR. 2.290.860.089,50; IRR value is 18.0% and the payback period is 3 years 10 months.

For further research, to provide an efficient analysis, the model and technique in this research need to be implemented in a Decision Support System (DSS). The DSS will possibly provide a quick analysis to assist managers to decide which locations and criteria to be considered in developing 5G technology in the future.

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