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Article

Combination of spatial dimensions and fuzzy analytic hierarchy process (F-AHP) for efficient selection of potential industrial zone in the Northern West Java, Indonesia

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Abstract: Industrial zones require careful and meticulous planning because industry can have a major impact on the surrounding environment. The research location is the northern part of West Java Province which is a gold triangle area named Rebana Triangle Area. The purpose of this study is to measure the weight of the research variables in determining industrial zones from the results of fuzzy analytical hierarchy process (F-AHP) analysis, assessing the location of industrial zones in the research area based on important variables in determining industrial zones. The result of this study is the weight of the research variables in determining the industrial zone from the results of the fuzzy analytical hierarchy process (F-AHP) analysis obtained is the availability of electrical infrastructure with an influence weight of 15.00%. The second most influential factor is the availability of telecommunications infrastructure with an effect of 13.02%, the distance of land to roads and access of 11.76%, land use of 11.21%, distance of land to public facilities of 9.99%, labour cost work is 9.60%, the distance of land to the river is 8.19%, the price of land is 7.97%, the slope is 6.79%, and the type of soil is 6.43%. This GIS analysis model can be a reference model for the government in determining the potential of industrial zones in other regions in Indonesia. A total of 4822.41 Ha or the equivalent of 3.50% of the total area of 6 (six) regencies/cities research areas which are very suitable to be used as industrial zones. The district that has the largest area of potential industrial zone is Majalengka, while Cirebon does not have a location that has the potential for industrial zone locations. Based on the results of the analysis of 10 (ten) variables for determining industrial zones from expert opinion, a draft policy proposal for the government can be proposed, among others. These 10 (ten) variables are variables that are expected to be mandatory variables in planning and determining the location of potential industrial areas.

Keywords: industrial zone; site selection; GIS; fuzzy and AHP

1. Introduction

Industrial zone requires careful planning and thoroughness because industry can have a big impact on the surrounding environment. When building a commercial building for business purposes, it all starts with all that is necessary for the business. This is where the selection of the location plays an important role which will make it possible to properly plan the business location. One of the problems that occur in Indonesia is de-industrialization which is a negative (premature) phenomenon of de-industrialization. This negative de-industrialization can be caused by shocks to the national economy, such as a decrease in the level of investment, a decline in foreign trade performance, a decrease in imports of raw materials, and the large number of imported products for consumer goods (Winardi et al., 2019).

The government has made several efforts to overcome negative deindustrialization occurring in Indonesia. Since 2014, the government has prepared an Economic Policy Package (PEK) related to industry. The PEK aims to reduce negative de-industrialization with one of the policies is to facilitate the process of investment in industrial zone, especially in 8 (eight) special economic zones. Of the various deregulations, to date, their effectiveness is still being questioned in overcoming de-industrialization in Indonesia (Winardi et al., 2019).

Economic growth as part of the sustainable growth process is an important indicator for measuring the success of a country's development (Chen and Xie, 2019; Tondaro et al., 2003). Indonesia continues to strive to increase economic growth, one of which is by increasing industrialization. Although it is not the ultimate goal of economic development, industrialization is an effort to achieve a high and sustainable growth rate which will ultimately create a high per capita income.

The developing industrial revolution has convinced many countries that the dominant criterion for economic development is an increase in per capita income caused by industrialization (Han et al., 2017). Therefore, it can be concluded that industrialization is a process of interaction between technological developments, innovation, production specialization, and trade between countries which in turn is in line with an increase in people's income which encourages changes in the economic structure (Kaldor, 2007).

1.1. Location of study

The research location is part of the northern region of West Java Province Indonesia in part of the Regency in West Java Provinces, namely Subang, Indramayu, Cirebon, Cirebon, Cirebon, Majalengka and Sumedang regencies. Some of the regions are affected areas of the construction of several infrastructure such as the Palimanan Cikampek Toll Road (Cipali), Kertajati Airport and the construction of the Patimban Port in Subang Regency which is expected to be a supporting port for Tanjung Priok Port in Jakarta Capital City. The development of infrastructure such as airports and ports provide easy access to transportation for industrial players, so that the area in the area between these three infrastructures is called the Cirebon, Patimban, Kertajati triangle area as the Gold Area for industrial zone.

The triangular area of Cirebon, Patimban, Kertajati (Rebana) is expected to become the economic backbone of the Java corridor in the future (**Figure 1**). In this area, 10 industrial areas and new cities will be built, 6857 companies, 13 sectors, 38,352 hectares of residential land, and 3.39 million residents. Apart from that, the benefits of this development will be electricity, water, data center and security resources, special economic zone opportunities, and permits or licenses for at least 10 potential locations which from a spatial planning aspect are suitable such as being outside rice fields and protected forests. These 10 candidate locations in the regional detailed spatial plan document are intended for new cities and rural settlements (Ramdhani, 2020).

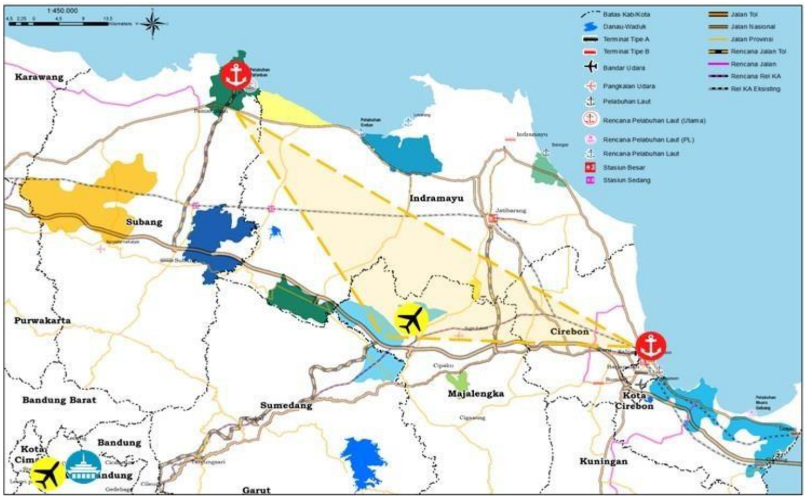


Figure 1. Location of study: The gold triangle area named Rebana Triangle Area.

1.2. Problems to objectives

This research aims to obtain more optimal results, with the AHP method added with fuzzy analysis and implemented in a case study of the use of spatial analysis using the GIS method. Other research with the same variables is used for macro analysis such as determining warehouses using different methods such as Multi Criteria Decision Making (MDCM), or the AHP method without combining it with the fuzzy method. According to Lootsma (1997) in the study of Elveny M and Rahmadsyah (2014), although AHP is commonly used to handle qualitative and quantitative criteria in MCDM, F-AHP is considered better at describing vague decisions than traditional AHP.

Based on Republic of Indonesia Government Regulation No. 142 of 2015, the government has the authority to provide 5 (five) industrial infrastructure, including energy and electricity networks, telecommunications networks, water resources networks and guaranteed supply of raw water, sanitation and transportation networks. F-AHP analysis and a combination of spatial analysis with 10 (ten) variables that complement Republic of Indonesia Government Regulation PP No. 142 of 2015 is expected to accommodate the needs of the government, industrial zone managers and investors so as to produce better information in determining the optimal location of industrial zone and to overcome negative de-industrialization problems that have a negative impact on industries in Indonesia. Based on explanation above, the following research problems can be formulated:

1) How is the weight of each variable in determining the location of industrial zone based on the fuzzy analytical hierarchy process (F-AHP) method?
2) What is the level of suitability of each region based on geographic information systems (GIS) and fuzzy analytical hierarchy process (F-AHP)?

2. Literature review

2.1. Industrial zone

Industrial zone are special areas or areas established to create a business-friendly environment. This business-friendly environment is, of course, an environment that can optimize business from upstream to downstream. Industrial zone is formed to increase business and develop locations, usually industrial zone will form a "new city" complex with business infrastructure. Industrial zone has a tendency to be formed based on government objectives to optimize resources in a location. This makes industrial zone have certain themes that are identical to the identity in which the location is developed.

The theory related to industrial zones is very interesting to research. This is related to how the government must provide public facilities, especially infrastructure, so that industrial companies can compete, companies that are located together produce an agglomeration economy; and public goods must be concentrated in a good supply chain. If the company is not already in a location, the provision of infrastructure will encourage investment. If the area is restricted, and the existing economic environment becomes expensive, exceptions can be made that will attract more firms and create competitiveness, in this case making the area most commonly referred to as "special economic zones", or SEZs (Saleman and Jordan, 2014).

Another opinion related to industrial zones by the World Bank (2012) in the study of Saleman and Jordan (2014), industrial zone are special areas (a piece of land) that are separate from urban and densely populated areas, and are categorized specifically for the location of industrial facilities. Industrial zone must support suitable infrastructure such as roads, electricity, water supply and other utility services to all facilities located within well defined area parameters.

Based on the above explanation regarding industrial zone, it can be said that industrial zone must have facilities that support the business world, have certain themes or objectives that tend to be specific. Industrial zone was formed to create an area conducive to creating a competitive business environment separate from the existing city.

2.2. Geographic information system (GIS)

Geographic information system (GIS) is a computer-based tool that functions to analyze, store, manipulate, and visualize geographic information. Mapping the area using GIS after getting the results from statistical analysis and making predictions. GIS is indirectly a method for analyzing spatial dimensions.

Spatial analysis provides the basis for the integration and collection of data at different spatial scales and time dimensions. Data integration is the main function of GIS applications. Exploratory spatial data analysis is a collection of techniques for configuring and visualizing spatial distribution, identifying atypical locations or spatial outliers, finding patterns of spatial association, clusters or hot spots, and suggesting spatial regimes or other forms of spatial heterogeneity (Anselin, 1994, 1999). Spatial modeling techniques, such as regression analysis can be applied to explicitly include the mechanisms underlying spatial patterns.

Geographical information system (GIS) according to Raper (1994) in the study of Prahasta (2014) defines GIS as a computer-based system that is able to integrate location descriptions with the characteristics of the phenomena found in that location so that it can support spatial decision making. A complete GIS includes the necessary methodologies and technologies, such as spatial data, hardware, software, and organizational structures.

Geographical information systems (GIS) have a major role in making spatial models. Making real world models in spatial form makes it easier to understand the study by reducing a number of its complexities. The variables used in modeling are implemented in database terminology (Prahasta, 2014). The data used in spatial modeling can be of various types obtained from various sources. Such data can be obtained through tabular data, remote sensing, maps, field data (terrestrial), and statistical data. The results of spatial modeling can involve a number of calculations and evaluation of mathematical logic so that relationships or patterns found in spatial elements can be found through spatial analysis.

2.3. Analytical hierarchy process (AHP)

Analytical hierarchy process (AHP) is a method developed by Saaty (1994) to determine factor priority scale decisions on a problem by considering the dominance of an element's relationship with other elements on certain attributes. In complex situations, the determination of priority scale decisions is not only influenced by one criterion but by multi-criteria. This analysis is used to model problems that have no structure and are not measurable. Decision making is done qualitatively based on comparison of perceptions, experiences, selection, and evaluation of experts who are closely related to the problem. This analysis begins by describing the multicriteria complex problem in a structured manner into a hierarchy. According to Albayrak and Erensal (2004) the hierarchy consists of at least three levels: (1) the objective of the problem is located at the top level, (2) multi-criteria alternatives in the middle, and (3) alternative decisions at the bottom. The next stage is to compare alternatives and criteria using a pairwise comparison matrix based on the intensity of interest comparison scale. The pairwise comparison matrix is shown in the following equation:

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix}, a_{ii} = 1, a_{ji} = \frac{1}{a_{ji}}, a_{ji} \neq 0$$

where matrix A is matrix $n \times n$ which has elements a_{ij} ($i, j = 1, 2, ..., n$).

2.4. Fuzzy logic

Fuzzy logic is a development of simple Boolean logic which only considers binary conditions, namely 0 (no) and 1 (yes). Fuzzy logic introduced by Zadeh (1965) in the study of Wardhani et al. (2011) is an approach that considers the degree of truth in the range of values from 0 to 1. This logic is able to configure geographical phenomena naturally. The concept of fuzzy-set is an effective method to overcome uncertainty in geographic data classification (Bhowmick, 2014). Each fuzzy set can be represented using a membership function. The membership function is configured with a curve that shows the input data according to the degree of membership (Wardhani et al., 2011).

The membership functions include triangle, trapezoid, gaussian, bell, and sigmoid. The degree of membership in fuzzy-AHP analysis is arranged based on the linguistic set using the triangular membership function. In general, the triangular membership function is defined by the symbol A (a, b, c) based on the following equation:

$$\mu A(u) = \begin{cases} 0 \\ (x-a)/(b-a) \\ (b-x)/(c-b) \\ 0 \end{cases}$$

2.5. Fuzzy analytical hierarchy process (F-AHP)

Fuzzy analytical hierarchy process (F-AHP) is a method developed by combining the AHP method with the fuzzy concept approach. F-AHP conducts decision analysis by considering qualitative and quantitative information and combines the two by describing the problem in a structured manner to provide alternative rankings based on a number of criteria (Chen, 2008). This theory is designed to cover the shortcomings of the conventional AHP method, namely by developing linguistic variables based on subjective judgments from experts in the fuzzy scope using the triangular fuzzy number function symbolized by A (a, b, c). Therefore, the ratio scale used in the pairwise comparison matrix in this analysis uses the fuzzy scale value.

Fuzzy extent analysis (FEA) is a technique for calculating the triangular fuzzy number value that is most widely used in the F-AHP method by Ding (2008) in the study of Wang (2008). This technique was developed by Chang (1996) to obtain the expansion of an object in order to fulfill the objectives, however Wang et al. (2006) conducted an evaluation of the FEA technique which showed that the technique was not good at estimating weight, that is, it has a chance of being zero if there are two fuzzy numbers. do not intersect (overlap). In making decisions, parameters that have zero weight are no longer considered. Therefore, the calculation cannot represent the importance of the existing criteria. Then in the study of Wang (2008) the technique is improved so that the weight generated in the calculation can be accepted and used in decision making.

3. Methods

3.1. Conceptual model

The research conceptual model is a model that shows a logical relationship between the variables that have been identified as important for analyzing research problems (Sinulingga, 2014). The conceptual framework is built based on previous theory and research so that it is integrated as a unit. The determination of industrial zone is strongly influenced by variables related to the need for carrying out industrial zone activities.

The conceptual model of this study begins by determining important factors in determining industrial zone based on previous regulations and studies. These variables are divided into several more specific variables based on the research of Chumaidiyah et al. (2020). In this study, there were four variables with a total of ten sub-variables, but all sub-variables had the same treatment in the AHP calculation process, which resulted in a total value of one hundred percent. Based on this analysis, it is concluded that the ten variables are no longer sub-variables, but are used as variables that affect industrial zone (**Figure 2**).

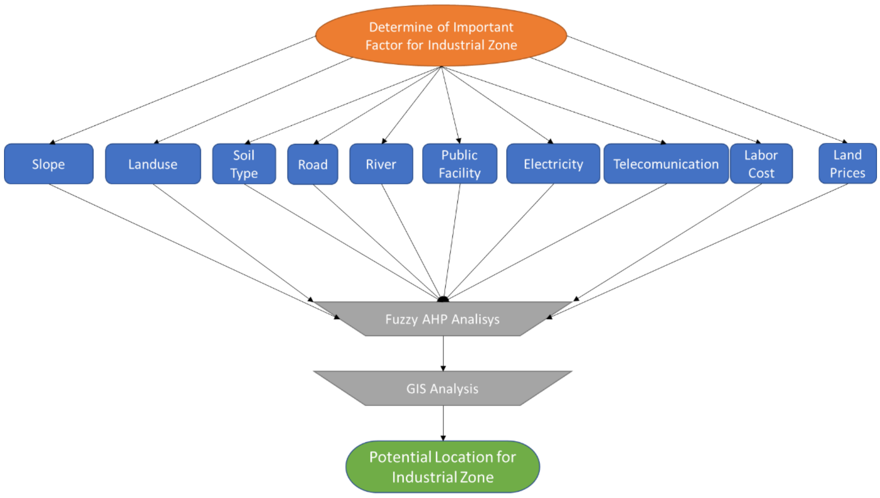


Figure 2. Conceptual model.

3.2. Research variable

According to Pratiknya (2007), in general the criteria for considering location selection in the development of industrial areas in Indonesia include criteria such as having primary arterial roads, electricity and telecommunications networks, slopes of 0–15 degrees, non-agricultural land, non-settlement and non-conservation (see **Table 1**).

Table 1. Operationalization of variable for industrial zone suitability.

No	Variable	Explanation	Data type	Classification reference	Number of suitable classes
1	Slope	Topographic conditions suitable for industrial areas	Interval	Albertus, 2018	5
2	Land use	Current land cover as a starting point for planning	Interval	Albertus, 2018	5
3	Soil type	Soil fertility level	Interval	Albertus, 2018	5
4	Road	Distance of land to road access supporting transportation	Interval	Albertus, 2018	5
5	River	Distance of land to the river as a source of industrial raw water	Interval	Albertus, 2018	5
6	Public facilities	Distance of land to supporting infrastructure public facilities	Interval	Albertus, 2018	5
7	Electricity	Availability of electrical networks for industrial activities	Interval	Fernando and Thanuja, 2014	5
8	Telecommunication	Availability of telecommunications networks for industrial activities	Interval	Fernando and Thanuja, 2014	5
9	Labor wages	Current labor costs	Interval	Chumaidiyah et al., 2020	5
10	Land price	Investment costs in land acquisition for industrial areas	Interval	Chumaidiyah et al., 2020	5

4. Data collection

Analysis of fuzzy analytical hierarchy process (F-AHP) with the conditions that the variables used have been determined, the next step is to carry out the data collection process. This process is carried out using a questionnaire filled out by expert respondents. Respondents were asked to compare between one variable and another based on level of importance using a paired matrix with importance intensity as configured in **Table 2** below.

Table 2. Intensity of interest AHP (Kadarsah, 1998).

Intensity of Interest	Description
1	The two elements are equally important
3	One element is slightly more important than the other
5	One element is more important than the other elements
7	One element is clearly more absolutely essential than any other
9	One element is absolutely more important than any other
2, 4, 6, 8	The values between two adjacent value considerations
The opposite	If for activity *i* gets one number compared to activity *j*, then *j* has the opposite value compared to *i*

Respondents from this research can represent the experts and practitioners related to industrial zone. Respondents for this study are expected to represent several stakeholders as follows:

1) Industry practitioner, an industry practitioner is expected to be a respondent to absorb information on how the industry chooses a location to carry out its industrial activities.
2) An industrial zone manager is expected to be a respondent to absorb information related to experience in managing industrial zone, how industrial zone company commonly referred to as tenants, determine industrial zones needed for industrial activities.
3) Industrial engineering experts, in this case it is expected to get a respondent who has expertise in industrial engineering, such as an industrial engineering lecturer.
4) Urban planning expert, in this case it is expected to obtain a respondent who has expertise in urban area planning, especially in relation to plans for the formation of industrial zone such as a lecturer in urban planning engineering.
5) Representatives of government agencies, in this case, are expected to obtain the point of view of policy makers from government agencies authorized in planning industrial zone.

5. Results and discussion

5.1. Numerical results

The results of the AHP method from five expert respondents in Industrial zones are to determine the most important criteria in determining new industrial zones based on these ten criteria. Data collection is done by determining the scale using the pairwise comparison method so that the relative importance of one criterion and another can be seen.

Then add the values in each row of the normalized matrix and then divide the total elements to get the priority vector. Followed by determining the weighted sum vector (WSV), this stage is done by multiplying each element of the pairwise comparison matrix with the priority vector. It is continued to calculate the consistence vector (CV) by dividing the results from the WSV with the priority vector value of the pairwise comparison matrix and calculating the lambda which is the average value of the CV. From the calculation results obtained CR value of 0.6 which means consistent. This is based on the conditional value of the consistency value for 10 variables that must be below 1.49 based on fuzzy random index value by Oarkridge Laboratory. The next stage is the incorporation of the paired matrix arrangement of five respondents in one table to facilitate the next fuzzy calculation process.

In this assessment, the fuzzy value of a parameter with other parameters is taken into account. The fuzzy value in question is a figure of the boundaries of a parameter that has overlapping effects with other parameters based on the input from the assessment of the intensity of interest in accordance with the logical view of each expert respondent. The use of fuzzy principles in the AHP method is intended to reduce subjectivity to the assessments given by expert respondents. The next stage is the preparation of an integrated fuzzy comparison matrix. This stage is carried out to convert the value into a fuzzy value for the variable. The input value in the form of the intensity of interest between parameters processed using F-AHP allows one parameter to have the same weight as the other parameters. The next stage is the creation of a triangular graph that shows the value of the fuzzy weight (*w*) at the values of *l*, *m*, *u* based on the combined opinion of the three expert respondents. Based on the graph (**Figure 3**), it can be seen that there is a wedge in each individual behavior variable. The intersection defines a fuzzy region between two or more parameters, which indicates that these parameters have a not much different effect.

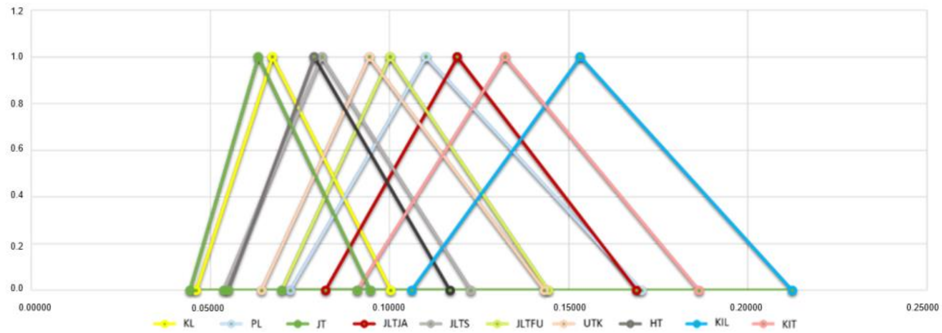


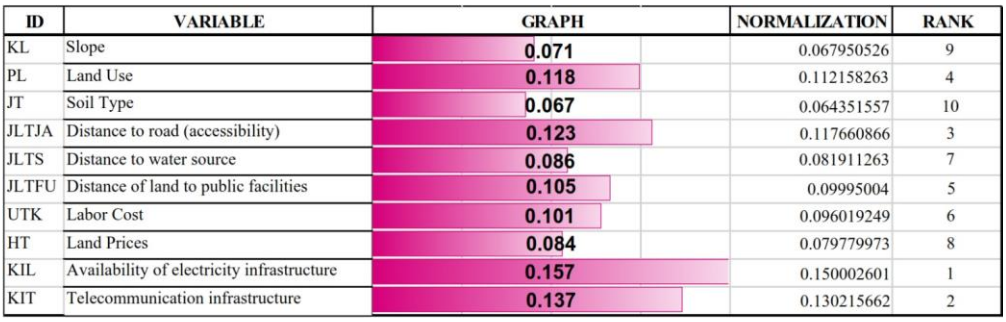
Figure 3. Fuzzy triangular graphics.

Through the fuzzy-AHP method, the overlapping areas can be de-fuzzified to get a non-fuzzy value in the form of final weight (BNP). In addition to the value of the intensity of interest based on expert respondents’ assessments, the final weight produced is also influenced by the number of respondents who gave an assessment.

The best non-fuzzy performance (BNP) value is normalized so that it can present the final weight for each variable that is used to determine the location of potential industries. The BNP value is the result of the defuzzification process of the triangular fuzzy number (TFN) value in the form of vector values (*l*, *m*, *u*) based on the assessment of each expert respondent, shown in **Table 3** and **Figure 4**.

Table 3. Definitive weights (BNP).

	Geometric average			The weight of each criterion			Definitive weight
	r			***w***			BNP
	l	***m***	***u***	***l***	***m***	***u***	
KL	0.5767	0.6986	0.8601	0.0461	0.0673	0.1003	0.071
PL	0.9047	1.1439	1.4597	0.0723	0.1102	0.1703	0.118
JT	0.5553	0.6581	0.8112	0.0444	0.0634	0.0946	0.067
JLTJA	1.0281	1.2349	1.4484	0.0821	0.1189	0.1690	0.123
JLTS	0.6719	0.8430	1.0521	0.0537	0.0812	0.1227	0.086
JLTFU	0.8744	1.0401	1.2370	0.0699	0.1002	0.1443	0.105
UTK	0.8050	0.9803	1.2280	0.0643	0.0944	0.1433	0.101
HT	0.6885	0.8202	1.0021	0.0550	0.0790	0.1169	0.084
KIL	1.3292	1.5908	1.8203	0.1062	0.1532	0.2124	0.157
KIT	1.1382	1.3728	1.5976	0.0909	0.1322	0.1864	0.137
TOTAL r	8.5721	10.3828	12.5164			Total	1.048
1/r	0.116658	0.096313	0.079895				



ID	VARIABLE	GRAPH	NORMALIZATION	RANK
KL	Slope	0.071	0.067950526	9
PL	Land Use	0.118	0.112158263	4
JT	Soil Type	0.067	0.064351557	10
JLTJA	Distance to road (accessibility)	0.123	0.117660866	3
JLTS	Distance to water source	0.086	0.081911263	7
JLTFU	Distance of land to public facilities	0.105	0.09995004	5
UTK	Labor Cost	0.101	0.096019249	6
HT	Land Prices	0.084	0.079779973	8
KIL	Availability of electricity infrastructure	0.157	0.150002601	1
KIT	Telecommunication infrastructure	0.137	0.130215662	2

Figure 4. Final weight and variable influence rating.

5.2. Graphical results

5.2.1. Spatial data processing

A. Slope

Slope spatial data were analyzed using basic data from the Indonesian Topographical Map (RBI). The data processing begins with reclassification referring to the classification reference suitable with the suitability classification of slopes for industrial zones. The result of this process is the slope suitability class map (industrial zone). In general, the results of the reclassification show that the flatter slope, the more suitable it is for industrial zones, this can be related to the level of vulnerability to ground movement so that it does not damage the building.

B. Land use

Land use spatial data was analyzed using one map (geospatial information agency) basic data. The data processing begins with reclassification referring to the classification reference suitable with the suitability classification of land use for industrial zones (**Figure 5**). In general, the reclassification results show that the most suitable land use for industrial zones is plantations. The rice field area is categorized as not highly suitable because the industrial zone development process should not damage the rice field area which is important for national food security.

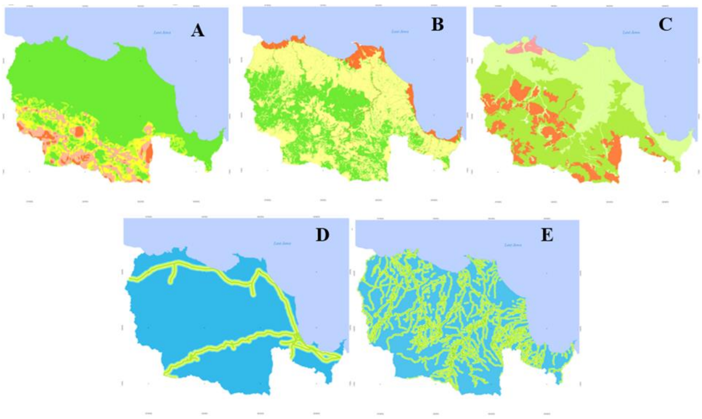


Figure 5. Suitability class map for industrial zone; **(A)** slope; **(B)** land use; **(C)** soil type; **(D)** land access; **(E)** surface water source.

C. Soil type

The spatial data of soil types were analyzed using basic data from the Indonesian Geospatial Information Agency (BIG) Geospatial Information Map (BIG) as administrative boundaries and sourced from the Center for Research and Development of Agricultural Land Resources (Ministry of Agriculture) for soil types. The data processing begins with reclassification referring to the classification reference suitable with the suitability classification of soil types for industrial zones. In general, the results of the reclassification show that the type of soil is suitable for industrial zones.

D. Land access

Spatial data on land accessibility was analyzed using the Indonesian Geospatial Information Agency (BIG) Geospatial Information Agency (BIG) base data. The data processing begins by performing a buffer analysis of toll roads, arterial roads and collector roads. Buffer analysis was carried out for five classes of land distance to the road suitable with classification. In general, the closer the land is to the road, the better the level of accessibility for industrial zones.

E. Surface water source

Spatial data on surface water sources were analyzed using the Indonesian Geospatial Information Agency (BIG) Geospatial Information Agency (BIG) base data. The data processing begins by performing a buffer analysis of the stream. Buffer analysis was carried out for five classes of land distance to the river suitable for classification, (**Figure 6**). In general, the closer the land is to the river, the closer it is to surface water sources, so the better for industrial zones.

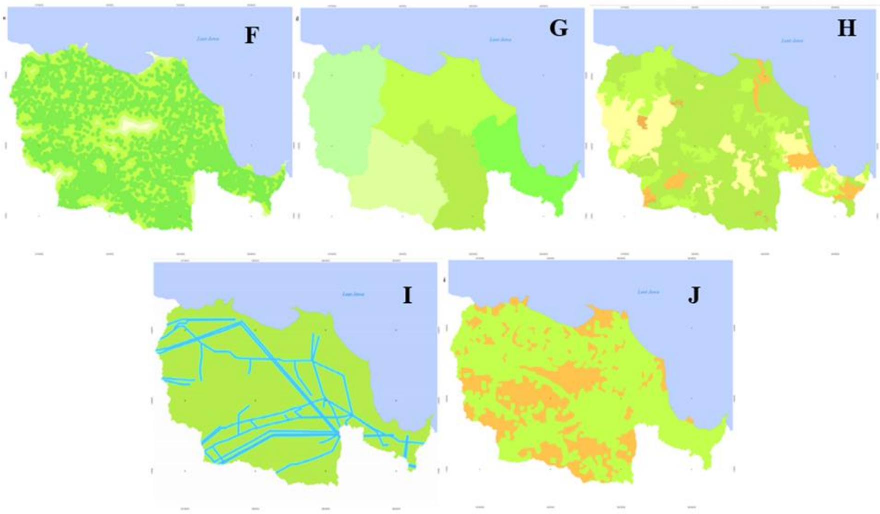


Figure 6. Suitability class map for industrial zone; **(F)** public facility; **(G)** labor cost; **(H)** land prices; **(I)** electrical infra; **(J)** telecommunication infra.

F. Public facilities

Spatial data for public facilities were analyzed using the Indonesian Geospatial Information Agency (BIG) Geospatial Information Agency (BIG) base data. The data processing begins with performing buffer analysis from various public facilities. Buffer analysis was carried out for five classes of land distance to public facilities Suitable with classification. In general, getting closer the land to public facilities, the better for industrial zones, this makes the process of preparing industrial zones more efficient considering the availability of public facilities to support industrial zone operations.

G. Labor cost

Regional labor cost spatial data were analyzed using the Indonesian Geospatial Information Agency (BIG) Geospatial Information Agency (BIG) as the administrative boundary. The data processing begins by analyzing the data combining through spatial data attributes with regional minimum wage data for each regency. The next analysis is that reclassification made for the five classes of suitability of the regional minimum wage suitable with the classification. In general, the cheaper the regional minimum wage, the better, this affects the company's operational costs in an industrial zone.

H. Land price

Spatial data on land prices were analyzed using basic data from the Indonesian Geospatial Information Agency (BIG) Geospatial Information Map (RBI) as administrative boundaries and land value data from the National Land Agency (BPN) for land prices. The data processing begins with analyzing the data pooling through the spatial data attribute of land prices. The next analysis is that reclassification is made for the five suitability classes of land values. In general, the cheaper land prices are, the better for industrial zones, this affects the investment costs of companies operating in an industrial zone.

I. Electrical network availability

The spatial data was analyzed using basic data from the Indonesian Geospatial Information Agency (BIG) Geospatial Information Agency (BIG) as the administrative admin boundary and land value data from the National Land Agency (BPN) for land prices. The data processing begins with analyzing the data pooling through the spatial data attribute of land prices. The next analysis is the reclassification for the five suitability classes of land values. In general, the cheaper land prices are, the better for industrial zones, this affects the investment costs of companies operating in an industrial zone.

J. Availability of telecommunication network

The spatial data of the telecommunications network is analyzed using the basic data of the Indonesian Geospatial Information Agency (BIG) Geospatial Information Map (RBI) as administrative boundaries and the availability of telecommunications network data as thematic data. The data processing begins with analyzing the combination of data through the spatial data attributes of the availability of telecommunication networks. The next analysis is that reclassification is carried out for the two suitability classes of telecommunication network availability suitable with the classification. In general, industrial zones should ideally already have a communication network so as to facilitate operations in the current industrial 4.0 era which requires rapid levels of digitization and information.

5.2.2. Analysis of potential industrial zone location

The GIS analysis used in this study is an analysis of map overlap for all research variables that already have score and weight attributes for each industrial zone suitability class based on F-AHP analysis based on data from expert respondents on 10 (ten) influential variables. All the weights of these variables are then classified into the suitability class for the location of the industrial zone. There are five suitability classes, which consist of areas that are highly suitable (blue), moderately suitable (light blue), marginally suitable (yellow), currently not suitable (orange), and permanently not suitable (red), shown in **Figure 7**.

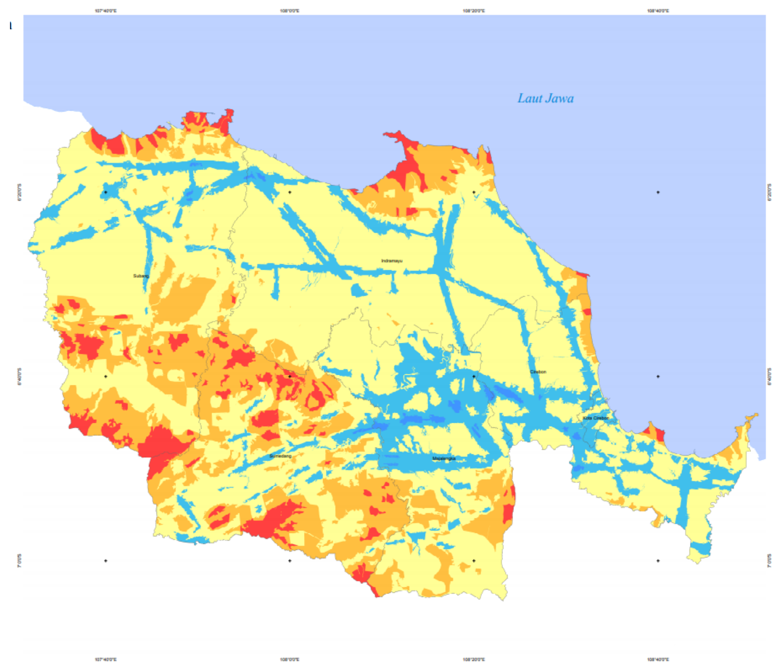


Figure 7. Industrial site land suitability class map.

The distribution of the entire land suitability class area can be seen on the land suitability class map for industrial locations, shown in **Table 4**. Class S1 (very appropriate) shows that based on the analysis of ten research variables, the area is highly recommended for industrial zone locations and this class is the optimal area recommended for industrial zone policy design. Class S2 (sufficiently appropriate) describes an area that still needs some improvement in order to become an optimal location for an industrial area. S3 class (marginal appropriate), this class needs more upgrades to become a suitable area for industrial zones. It takes a lot of consideration to make this class a suitable location for an industrial area. Class N1 (not appropriate at this time) is an area that is physically supported to be used as an industrial area. However, there is still a lot of improvement related to the need to become an industrial area. This area in the future with all the development of the city does not rule out the possibility of being a potential area to build an industrial area, but of course it cannot be recommended as an industrial area for now. Class N2 (permanently not appropriate) is an area that cannot be called an industrial area even though there are changes or developments in the coming year. This area is an area that tends to be located in areas with high slopes which are mountains and natural forests that must be preserved but there are no areas with this classification based on the results of the analysis in the research area. The development of industrial zones in this location is very risky and inefficient for industrial players.

Table 4. Area of land suitability class for industrial zone.

No	Regency	Very Appropriate (S1)	Appropriate (S2)	Marginal Appropriate (S3)	Not Appropriate at this Time (N1)	Permanently Not Appropriate (N2)	Total
		(Ha)	(Ha)	(Ha)	(Ha)	(Ha)	
1	Subang	326.47	20,586.38	122,925.04	65,511.05	16,499.34	225,848.28
2	Indramayu	274.19	33,434.43	150,592.68	48,605.51	4850.33	237,757.13
3	Cirebon	1405.78	33,680.49	66,851.77	7086.57	618.48	109,643.08
4	Kota Cirebon	0.00	2595.92	1325.98	0.00	0.00	3921.90
5	Majalengka	2596.30	42,249.75	72,002.47	24,663.07	1067.37	142,578.96
6	Sumedang	219.67	10,565.98	60,560.29	68,467.65	17,310.67	157,124.26
Total		**4822.41**	**143,112.95**	**474,258.22**	**214,333.85**	**40,346.18**	**876,873.61**

The table of land suitability areas for industrial locations is a summary of a number of 459,232 polygons that are classified into 5 (five) land suitability classes for industrial zones in each regency/city of the research area. The classification used is an equal interval where all values from the minimum to the maximum are divided by the mean value. The results show that there are a total of 4822.41 Ha or the equivalent of 3.50% of the total area of the entire regency/city which is the research area proposed to be used as an industrial area. 2. In total of 4822.41 Ha or the equivalent of 3.50% of the total area of 6 (six) regencies/cities research areas which are very suitable to be used as industrial areas. The district that has the largest area of potential industrial area is Majalengka Regency, while Cirebon City does not have a location that has the potential for industrial area locations. Details of each regency/city in the research area from the largest to the smallest, namely Majalengka

Regency has a potential industrial area of 2596.30 Ha, Cirebon Regency has an area of 1405.78 Ha, Subang Regency has an area of 326.47 Ha, Indramayu Regency has an area of 274.19 Ha, and Sumedang Regency covering an area of 219.67 Ha.

6. Conclusion

Based on the F-AHP analysis with 10 (ten) variables used in this study to determine the optimal location of the potential industrial zone, it can guarantee the following:

1) The weight of the research variable in determining the industrial area from the results of the fuzzy analytical hierarchy process (F-AHP) analysis obtained is the availability of electrical infrastructure with an influence weight of 15.00%. The second most influential factor is the availability of telecommunications infrastructure with an effect of 13.02%, the distance of land to roads and access of 11.76%, land use of 11.21%, distance of land to public facilities of 9.99%, labor wages work is 9.60%, the distance of land to the river is 8.19%, the price of land is 7.97%, the slope is 6.79%, and the type of soil is 6.43%.
2) In total of 4822.41 Ha or the equivalent of 3.50% of the total area of 6 (six) regencies/cities research areas which are very suitable to be used as industrial areas. The district that has the largest area of potential industrial area is Majalengka Regency, while Cirebon City does not have a location that has the potential for industrial area locations. Details of each regency/city in the research area from the largest to the smallest, namely Majalengka Regency has a potential industrial area of 2596.30 Ha, Cirebon Regency has an area of 1405.78 Ha, Subang Regency has an area of 326.47 Ha, Indramayu Regency has an area of 274.19 Ha, and Sumedang Regency covering an area of 219.67 Ha.

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