IJERA2023

by Augustinus Bayu Primawan

RESEARCH ARTICLE OPEN ACCESS

Sensitivity Analysis on GIS-based Multi-Criteria Decision Making of Access Point Placement Index: A Case Study of Priority Location in Access Point Placement Problem

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ABSTRACT
Criteria on the placement location of an access point are used to determine the priority of a location placed as an Access Point of a wireless computer network (Wireless Local Area Network). The model form was defined as an Access Point Placement Index. The model parameter can be defined as User (number of users), Line (the position of the access point), Building (type of building in which the access point is placed), and Density (ratio of users to the coverage of the access to information). The use of Geographic Information Systems (GIS) in the Multi-Criteria Decision Making (MCDM) requires additional analysis methods related to the sensitivity of the parameter value changes. Sensitivity analysis is used to find the effect of changes in the weights of each parameter within an access point placement model. SIG with its capabilities can be used to see the effect of such changes. The processing of raster data in combination with the "One at a Time" method can be used to search the sensitivity of each parameter in the Access Point Placement Index. The results of the sensitivity analysis show that the parameters associated with the access point location (Building, Line) are more sensitive to changes in weight compared with the parameters related to the user (User, Density). Therefore, the design and optimization of the placement of access points should pay more attention to these parameters.
***Keywords* -** GIS, Sensitivity Analysis, Placement Index of Access Point, Access Point Placement Position.

I. INTRODUCTION

A sensitivity analysis is an analysis performed to determine the result of changes in the parameters of a process toward the final outcome of the process [1]. In general, the sensitivity analysis is a study of the variations in the output of a mathematical model that can be seen from the quality and quantity of inputs. The use of such analysis, especially to seek parameter priority of research data. Other than that, the interest of the sensitivity analysis is for the verification and validation of the model used [2]. According to [3], one objective of sensitivity analysis is to identify the parameters of a parameter model including the top priority or not.

The application of sensitivity analyses has been carried out with a variety of methods in engineering, economics, and social sciences in the decision-making process. It has now expanded the use of sensitivity analysis in the integration of Geographic Information Systems (GIS) with Multiple Criteria Decision Making (MCDM). SIG-MCDM integration in land use decision-making by applying sensitivity analysis has been carried out by [4]. According to [5], the use of the analysis of sensitivity can reduce the uncertainty that occurs when the MCDM methods do and provide a stable use of the input data on the results of a model. Application of sensitivity analysis in the model GIS-MCDM was easy when evaluating the final results of a model [6], [7].

GIS-MCDM models used in this case study is a model of priority placement of the access point locations. The model is the result of the identification process by using the Analytical Hierarchy Process (AHP). Model placement of an access point location formulated in an equation called Access Point Placement Index (APPI). The resulting model is derived from the input of experts and a review of studies by questionnaire. The parameter-assessment questionnaire contains the parameters required to determine the criteria for priority in the case of the placement location of the access point. AHP is a method of analysis in the determination of plural criteria developed by [8].

Therefore, verification of the placement index model access point becomes important, given the parameters that have been set can be changed for different situations and conditions. The use of GIS application-MCDM by applying sensitivity analysis will be able to provide input on how far the weight variation of each parameter will affect the final result of the placement of the access point location index.

II. RESEARCH METHODS

A. Access Point Placement Index

Access Point Placement Index (APPI) is an index determining the priority areas of the placement of the access point of the wireless computer networks (WLAN-Wireless Local Area Network). There are three (3) criteria derived from the index, namely Low (Low Priority), Medium (Medium Priority), and High (High Priority). The parameters required in determining the location priority index are U (User), B (Building), L (Line), and D (Density). User is a parameter that indicates the number of users in an area that are accessing the internet through an AP (access point) or access point. Building is a parameter of the type of building where the user accesses the AP. This case study was conducted around the campus where types of buildings can be lecturing halls, administration buildings, laboratories, student dormitories, and other public areas. Line is a parameter that indicates the location of the AP inside or outside the building since one of the requirements for AP placement is the availability of an electrical power source. Density is a parameter that indicates the number of users per unit area at a particular access area. The weighted parameter calculation derived in Table 1 is based on questionnaire data from field measurement and an expert panel on relative importance in between APPI parameters[9].

TABLE I
WEIGHTS CALCULATION FOR APPI

	Building	Line	User	Density	weight	Norm
Building	0.06	0.04	0.04	0.09	0.23	0.057
Line	0.19	0.11	0.07	0.12	0.49	0.122
User	0.31	0.32	0.22	0.20	1.05	0.263
Density	0.44	0.54	0.66	0.60	2.23	0.558
	1.00	1.00	1.00	1.00	4.00	1.000

Source compiled by Author

Furthermore, the consistency ratio (CR) can be calculated as in Table 2 and its result is less than 10% so that model is consistent. The results of the modeling are as follows:

APPI = 0.057 B + 0.122 L + 0.263 U + 0.558 D (1)

The next model of the Equation 1 will be used as the Default Model in the sensitivity analysis. The model is used as a default model of comparative analysis with other study models.

TABLE II
CONSISTENCY RATIO CALCULATION

		Line	User	Density		Consistency
Building	1.00	0.33	0.20	0.14	0.23	4.04
Line	3.00	1.00	0.33	0.20	0.49	4.04
User	5.00	3.00	1.00	0.33	1.05	4.17
Density	7.00	5.00	3.00	1.00	2.23	4.22
	16.00	9.33	4.53	1.68	4.00	

CI	0.039
RI	0.900
CR	0.044

B. Area of Study

The area of study used is the area of campuses located in Pathumthani province, Thailand.

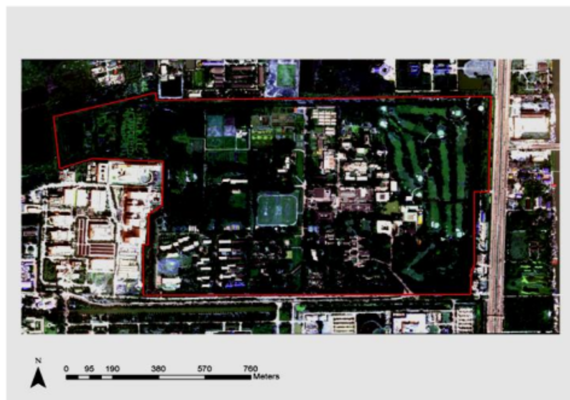

Fig. 1 Study Area

The research area is about 131 hectares consisting of academic buildings, laboratories, administrative buildings, student dormitories, and areas of open space. Specifically geographic projection system WGS 1984 UTM coordinates are N47. Coordinates of a location situated between 673215-674570 East longitude and 1556722-1557559 North latitude. AP placement locations generally consider the number of users, the location of the placement inside or outside the building (indoor or outdoor) and the location of the building is a lot to capitalize on internet access, especially in the context of learning and research activities in the campus area[10].

C. Sensitivity Analysis Procedure

Various methods approach the sensitivity analysis has been done of the differential method to Monte

Carlo, as well as regression-correlation to the variants-based method [5]. However, the approach to most simple sensitivity analysis is viewed because of changes in input variables to the output. This analysis method is known as "One At a Time" or methods of OAT. The advantage of the OAT method is the ease of implementation and calculation, and it has been widely used in various fields of research [11]. In this case study the sensitivity aspect of criteria weight is a major concern to see the stability of the results to changes in the value of the weight on some model's order.

D. Spatial modeling with GIS

The use of GIS allows the processing of geographic data on the spatial aspects of the attribute or non-spatial data, or a combination of both in an operating system. Analysis capabilities of GIS also provide flexibility in its use for a variety of applications based on spatial data. The quality of input data and calculation results is a very important aspect to be considered. Good quality input data will give the results of model calculations are good also. So that the reliability of the output will give a correct conclusion [4].

TABLE 3
VALUES COMBINED PERCENTAGE WEIGHTS FOR DIFFERENT MODELS OF PRIORITY AREA INDEX (%)

Model	User	Building	Line	Density
Default	26.03	6.61	11.53	55.83
1	30.00	30.00	30.00	**10.00**
2	23.33	23.33	23.33	**30.00**
3	13.33	13.33	13.33	**60.00**
4	30.00	30.00	**10.00**	30.00
5	23.33	23.33	**30.00**	23.33
6	13.33	13.33	**60.00**	13.33
7	30.00	**10.00**	30.00	30.00
8	23.33	**30.00**	23.33	23.33
9	13.33	**60.00**	13.33	13.33
10	**10.00**	30.00	30.00	30.00
11	**30.00**	23.33	23.33	23.33
12	**60.00**	13.33	13.33	13.33

Source: compiled by author

GIS-based sensitivity analysis using a method based on raster data. Raster Calculation is used to generate value calculation APPI by summing the multiplication of the weight and value of the parameter. The calculation result raster is then classified into three (3) values which are in this case the value of 1 (one) to indicate areas with Low Priority, 2 (two) for Medium Priority and 3 (three) to areas with High Priority. Variation changes in the weights for each model used in this sensitivity analysis are summarized in Table 3.

Each parameter was given three (3) variations in the value of the weight, respectively 10%, 30% and 60%. While the weight values for the other parameters are given the same value for each model. For example: the Model 1 Density weight value is set at 10%, then the value of the parameter weights User, Building, and Line scored equal weight, respectively 30%. And so on for each model from Model 2 to Model 12. The default Model is used as a comparison in data validation output. Twelve schemes are implemented and processed with the model in GIS. The output of each APPI calculated the percent area for each of the criteria for the prioritization and compared with each other for influence changes in the weights of the index value of the location of placement. The comparison results can be obtained by how sensitive changes to the weight of its output are to be summed up the results of the sensitivity analysis on a case study of priority placement of the access point locations.

III. Result and Discussion

Results of raster data processing and tabulation of the value of the index priority locations are presented in Figure 2 through Figure 5. Each graph shows the output row for User parameters, Building, Line, and Density.

Figure 2 shows the results of data processing for the weight value changes User parameter, in this case the models No. 10, 11, and 12. The parameters relating to the number of users do not show significant changes when the weight value is changed. The results showed that the area with priority gained the highest score, followed by the area with medium and low priority. However, changes in the area are different from the conditions of Default priority.

In this case, a high-priority area has increased from 27% to 48%. While the area with medium and low priority declines. Medium priority decreased from 45% to 29%. While low priority decreases from 28% to 15%. These results suggest that changes in weight values for the User parameter is not sensitive to the outcome index priority locations.

Meanwhile, Figure 3 shows the results of data processing changes in weight values for parameter Building, in this case, models No. 7, 8, and 9. Parameters relating to the type of building show significant changes when the weight value is changed. The results showed that the area with high priority obtained the highest score, followed by the area of medium and low priority. While the change in the priority area also increased when compared to the default.

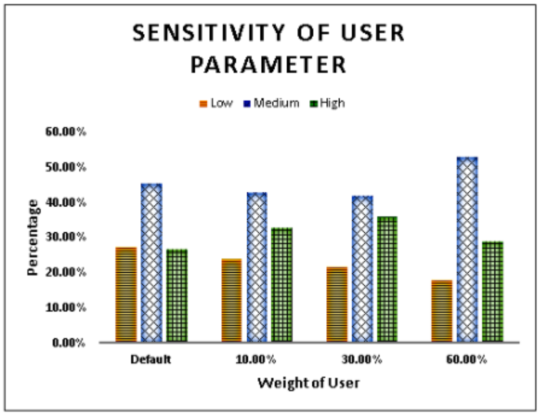

Fig.2 Sensitivity Analysis for User criteria (variation scheme of weight 10%, 30% and 60%)

In this case, the high-priority area has increased from 27% to 69%. While the area with medium and low priority declines. Medium priority decreased from 45% to 19%. While low priority decreases from 28% to 13%. These results suggest that changes in weight values for parameter Building are sensitive to the outcome index priority locations. The implication is that the parameter types of buildings as the location where users access the Internet network is a very significant impact on the index value of the priority locations.

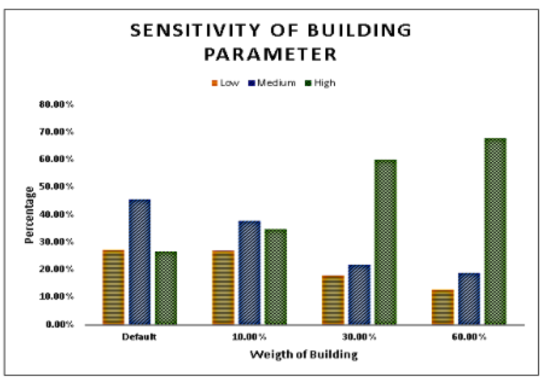

Fig.3 Sensitivity Analysis for Building criteria (variation scheme of weight 10%, 30% and 60%)

. Whereas in Figure 4 shows the results of data processing weight values for parameter changes Line, in this model no 4, 5, and 6. The parameters relating to the placement of indoor or outdoor location shows significant changes when the weight value is changed, the results showed that the vast areas with high priority obtained the highest score, followed by the area with medium and low priority. While changes in priority increased compared to the default condition.

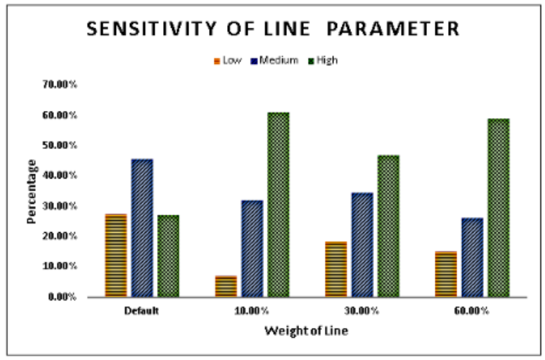

Fig.4 Sensitivity Analysis for Line criteria (variation scheme of weight 10%, 30% and 60%)

In this case, a high-priority area has increased from 27% to 59%. While the area with medium and low priority declines. Medium priority decreased from 45% to 26%. While low priority decreases from 28% to 19%. These results suggest that changes in weight values for Line parameters are sensitive to the outcome index priority locations.

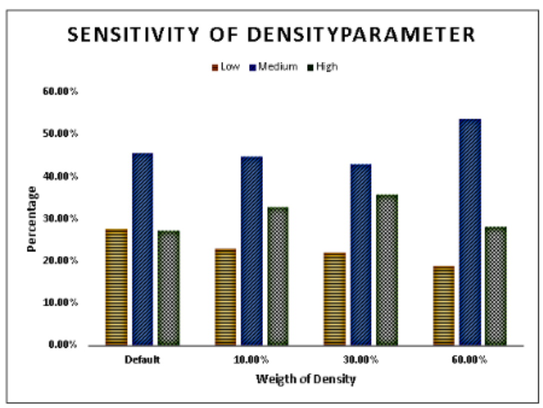

Fig.5 Sensitivity Analysis for Density criteria (variation scheme of weight 10%, 30% and 60%)

Furthermore, Figure 5 shows the results of data processing weight values for parameter changes Density, in this case the models No. 1, 2, and 3.

Parameters related to the number of users per unit area showed no significant changes when the weight value was changed, the results showed that the vast medium-priority areas with the highest score, followed by the areas of high and low priority. Similarly, changes for the area of priority were not significantly different from the default. In this case, high-priority areas have increased from 27% to 34%. While the area with medium and low priority declines. Medium priority decreased from 45% to 42%. While low priority decreases from 28% to 19%. These results suggest that changes in weight values for the parameter's Density are insensitive to the final outcome index priority locations.

The sensitivity analysis to changes in the index weighting parameter priority locations can also be calculated as a percentage of the aggregate to validate these findings. The aggregate percentage illustrates the level of sensitivity of each parameter to determine the outcome of the designation of priority. The equation used in the calculation of aggregate percentages is:

(2)

Rated X1, X2 and X3 a percentage value location index results for each criterion. N is the total maximum number of possible values. The calculation of the percentage of the sensitivity aggregate value of each parameter is presented in Figure 6.

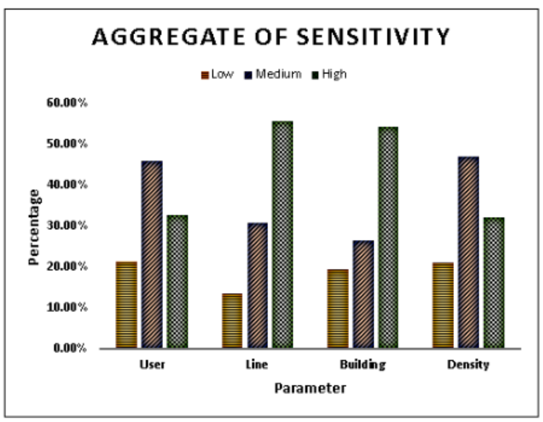

Fig.6 Aggregate of Sensitivity Analysis for each criterion.

The tabulated results show that the aggregate value parameter Line and Building giving high priority area has a higher value than the parameters User and Density. The percentage aggregate for high-priority criteria as the top priority of each successive parameter is Line valued at 0.55%, Building at 0.54%, User and Density at 0.47%, and 0.31% worth.

. So, the weight changes in both parameters (Line and Building) will strongly influence the outcome index priority locations. Therefore, the location where the access point is determined by the area where internet access is very high activity as well as the laying of the access point whether indoor or outdoor. Design and placement optimization of access points must pay attention to both parameters. However, the model equations that have been produced show that the weights for that parameter are smaller than the other two parameters, namely the User and Density

IV. Conclusion

This paper has discussed the method sensitivity analysis related parameters on priority area index constituent. The results of the sensitivity analysis show that a reference to the location of the access point, in this case, Building, and Line, is more sensitive to changes in weight compared with the parameters relating to the number of users of User and Density. Therefore, to plan the wireless computer network placement location of the access point is more focused on the criterion of the location in comparison to user criteria.

Acknowledgments

I would like to thank the Directorate General of Higher Education of The Minister of Research and Higher Education Republic of Indonesia for supporting this research.

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