# Decision Support Model for Selection of Location Urban Green Public Open Space

Fahrul Agus, Afif Ruchaemi, Lambang Subagyo and Soemaryono

**Abstract**—Traditional methods for managing green public open space in a city are to provide and conduct public forums and meetings. However, this approach has a limitation due to high mobility of key and important people in the community. A decision support system utilizing spatial science of green public open space emerges as another approach that will be discussed here, in particular by Participatory Web Based Geographic Information System Software (WebGIS). The aim of this research is to utilize WebGIS as the primary tools for planning and decision-making green open space management. The case study presented in the paper is WebGIS Decision Support preliminary model for Samarinda city - East Kalimantan, Indonesia. Multicriteria Decision Analysis – Analytical Hierarchy Process/AHP tools were used to produce the model. The preliminary result indicated that Citra Niaga is the most suitable for green public open space in Samarinda. In Summary, AHP tools can be used as an alternative to conventional method for decision support of space management.

**Index Terms**—Participatory WebGIS, Decision Support, Multicriteria Decision Analysis, Analytical Hierarchy Process, Green Public Open Space, Samarinda.

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## 1 Introduction

Public participation by means of meetings or forums is a traditional method for collaborating every stakeholder need in determining Green Public Open Space. However, the effectiveness of the traditional method in public participation is very limited, since the nature of the method is based on the same place and time (physical meeting, synchronous and co-located). Conventional models of public participation are also often criticized for having deficiencies in representing specific interest groups and local residents. This is because some individuals and groups cannot be present at certain times and locations, and may be unwilling to voice their unbiased interests in the presence of other community members. In addition, to facilitate effective public participation, spatial planning and decision-making procedures must be collaborative and distributed over a certain period [1], [2], [3].

Geographic Information Systems (GIS) and related computer hardware have been developed to allow decision making in spatially related issues. This innovation leads to GIS as a primary tool for planning and space management decision-making. However, the progress in the application of GIS to enhance public cooperation in the spatial decision-making still has many limitations, i.e. needs developed source maps and data to produce satisfying result [4], [5].

On the other hand, problems of urban areas are now more complicated in growing urban area like Samarinda, East Kalimantan, Indonesia. Along with the development of urban areas, causing problems in the development of land management, such as high and uneven population density, reduction in public infrastructure quality and quantity such as water supply, waste management, transportation and fewer public spaces such as green public open space and water catchment areas. These urban issues, if not managed properly, will result in land conflicts and cause damaging environmental problems, threatening the balance of ecology and nature.

For this, it is necessary to conduct a preliminary study related to a decision model for selecting the best location of urban green public open space in Samarinda city. This model will be integrated into the design model of web-based software to explore issues of community participation in the management of urban spaces especially the placement of green open space locations. This design is expected to be a reference for prototyping software; therefore allowing site selection of urban green public open space by means of participatory WebGIS.

## 2 Analitycal Hierarchy Process

The problem of decision-making can be a complex issue with regard to the involvement of multiple objectives and criteria (Multi-criteria Decision Analysis MCDA) [6],[7]. One of the tools used for the selection of suitable candidates or ordering priorities in the MCDA problem is the Analytical Hierarchy Process (AHP). This method has been developed by Thomas L. Saaty [8].

In a settlement with AHP there are several principles that must be understood, which are:

(a) Making Hierarchy
Complex systems can be understood by breaking it down into supporting elements, whereas composite elements hierarchically combined or synthesized into several groups of components.

(b) Assessment criteria and alternatives
Criteria and alternatives are done by pair-wise comparisons. For determination of some problems, a scale of 1 to 9 is used to express the opinions of stakeholders. Value definitions can be determined using qualitative opinion analysis tables as shown in Table 1.

TABLE 1
PAIRWISE COMPARISON SCALE ASSESSMENT

| The intensity of interest | Description |
|---|---|
| 1 | Both elements are equally important |
| 3 | One element is less important than any other element |
| 5 | One element is important than any other element |
| 7 | One element is more important than other elements |
| 9 | One element is absolutely more important than other elements |
| 2,4,6,8 | Values between two adjacent values should be in considerations |
| Inverse | If activity (i) got a point compared with activity (j), then (j) has the opposite value compared to (i) |

(c) Synthesis of priority
For each criteria and alternatives, pair-wise comparisons need to be done. Comparison of the relative values of all alternatives can be adjusted to the justification of the criteria that have been determined to produce weight and priority. Weights and priorities calculated by manipulating the matrix or through the completion of linear equations.

(d) Logical Consistency
Consistency has two meanings. First, similar objects can be grouped according to the uniformity and relevance. Second, regarding the level of relations between objects which are based on certain criteria.

Basically, the procedure or steps in the method of AHP include :

1 Defining the problem and determine the desired solution, then construct a hierarchy of problems faced. Preparation of hierarchy is to set goals that are targeted overall system top level.

2 Determining priority element
  a) The first step in determining the priority elements is to make pair comparisons, comparing pairs corresponding elements in a given criteria.
  b) Pair-wise comparison matrix is filled using numbers to represent the relative importance of one to another element.

3. Considerations for pair-wise comparisons were synthesized to obtain overall priorities. Things that are done in this step are :
  a) Add up the values of each column in the matrix.
  b) Divide each value by the total column and the column in question to obtain the normalization matrix.
  c) Add up the values of each row and dividing by summing the number of elements to get the average value.

4. Measuring Consistency
In making this decision, it is important to know how well the consistency is, because decisions should not be based on consideration of the low consistency. Things done in this step, are:
  a) Multiply each value in the first column with the relative priority of the first element, the value in the second column the relative priority of the second element, and so on.
  b) Sum of each row.
  c) The result of the sum of the line divided by the relative priority of the corresponding element.
  d) The number of results for the above with many elements are there, the result is called $\lambda_{max}$.

5. Calculate the Consistency Index (CI) by:
$CI = (\lambda_{maks} - n)/n$ ; n = number of elements

6. Calculate the Consistency Ratio (CR) by:
CR = CI / RI ; RI = Random Consistency Index

7. Check the consistency of the hierarchy. If the value is more than 10%, then the justification assessment data should be corrected. However, if the consistency ratio less than or equal to 0.1 (10%), then the calculation results can be substantiated.

For RI value is determined based on the size of the matrix as shown in Table 2:

TABLE 2
RANDOM CONSISTENCY INDEX VALUE (RI)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Matrix Size | 1,2 | 3 | 4 | 5 | 6 | 7 | 8 |
| RI | 0 | 0.58 | 0.9 | 1.12 | 1.24 | 1.32 | 1.41 |
| Matrix Size | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| RI | 1.45 | 1.49 | 1.51 | 1.54 | 1.56 | 1.57 | 1.59 |

## 3 APPROACHES AND RESEARCH METHODS

This study is an engineering research and consisted of modeling, prototyping, and manufacturing software. Therefore, this research work is done mostly in the lab. The activities of field visits made to collect primary or secondary data as a model of completeness for process analysis and software design. The visits used for the purpose of data validation. With the complete collection of data, the software will give a comprehensive analysis of the model so that the validity of design process system can be improved.

This study uses a comprehensive approach to the problem's background. A complete description about the problem of research is described in the picture of the framework think of the research below.

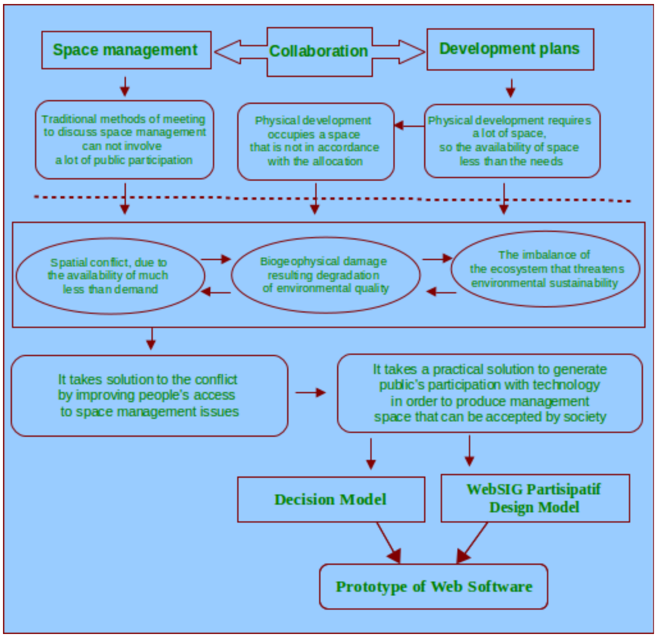


Fig. 1. Framework think of the research

This study also established criteria for economic, social and environmental and geographic conditions into eight variables or criteria to determine the best location on the green public open space, that is :

(1) The land area ($C_1$) in square meter ($m^2$), the broadest measure of the location is the best.
(2) Price of land ($C_2$) in rupiah per square meter ($Rp/m^2$), the location with the lowest price is the best.
(3) Number of people ($C_3$) around the candidate sites in population unit, it is assumed that the location of the least population in 100 meters is the most suitable.
(4) The level of pollution ($C_4$), the location with the highest levels of pollution were selected.
(5) Average distance to human settlements ($C_5$) in meter (m), the least average distance to the closest human settlement is the best.
(6) The maximum distance to human settlements ($C_6$) in meter (m), the longest maximum distance to the nearest human settlement is the best.
(7) The average distance from the city center ($C_7$) in meter (m), the least average distance to the closest city center is the best.
(8) The average distance from the main road ($C_8$) in meter (m), the least average distance to the closest main road is the best.

Sampling is required to determine the respondents as a source of primary data at the MCDA-AHP decision modeling. The modeling of policy or decision using AHP is research based on expertise judgment, i.e. research that requires respondents to understand the problems that the object of the study.

Determination of the key-person respondents is conducted with the non-purposive sampling probabilities. The sampling procedure is based on the specific purpose, in this case, it is expertise judgment and with the probability of an unknown. Therefore, respondents to the analysis of this model are set with quota sampling technique by twelve respondents that were divided into 2 groups. The first group of respondents belongs to bureaucracy, policy makers and implementers of management green public open space Samarinda City. The second group is the receiving end of green public open space such as academics, NGOs, corporate and community leaders.

The process of data analysis needed for decision modeling in spatial management, in particular the determination of the best location of green public open space in Samarinda, is conducted using MCDA-AHP. AHP included simultaneous assessment of both qualitative and quantitative decisions and set priorities in a way sums up the perception of people, and then convert intangible factors into rules that can be compared.

The step-by-step decision-making model of MCDA-AHP method is:

1) Defined goals based on the background of problems, which is the best location to set priorities in the management of green public open space in Samarinda.
2) Defined eight criteria for determining the location of green spaces (C1 to C8) and set 12 respondents who identified as key-person in the in-depth interview process to obtain data on the weight of priority.
3) To make a chart that illustrated the problem decomposition hierarchy structure model of the decision to be reached.
4) Doing the survey on in-depth interviews with 12 respondents and set 5 alternative locations chosen by most respondents to be used as a location candidate.
5) Doing weighting of five locations for which each candidate is based on established criteria. Weight value is determined based on observations in the field for each candidate. For this weighting, the value of the candidate against the criteria determined by the value of the following categories :
   - The same given a value of 1, the ratio of one to the other candidates of equal value
   - Medium given a value of 2, the comparison between the two candidates is medium value

- Highly given a value of 3, one candidate over the other candidates
- Contrary to the value of ½ and 1/3 for a comparison of candidates with opposite values

6) Constructing matrix pair-wise comparisons based on the average geometry of the priority weights of 12 respondents. Furthermore, this value is converted based on the value of the same category as categories weight with the following criteria :
   - Equal to the value of 1 for the intensity interest values 1, 2 and 3
   - Medium with a value of 2 for the intensity interest values 4, 5 and 6
   - Highly to the value of 3 for the intensity interest values 7, 8 and 9
7) Testing and validation of the consistency criteria and weight of candidates. If the value consistency is more than 10%, then the model is inferred as inconsistent and cannot be used as a reference model and needs the normalization matrix. However, if it is less than 10%, then the model can be reliable as a decision model.

Hierarchical structure of the decision model determining the best location green space in Samarinda city as described in Figure 2.

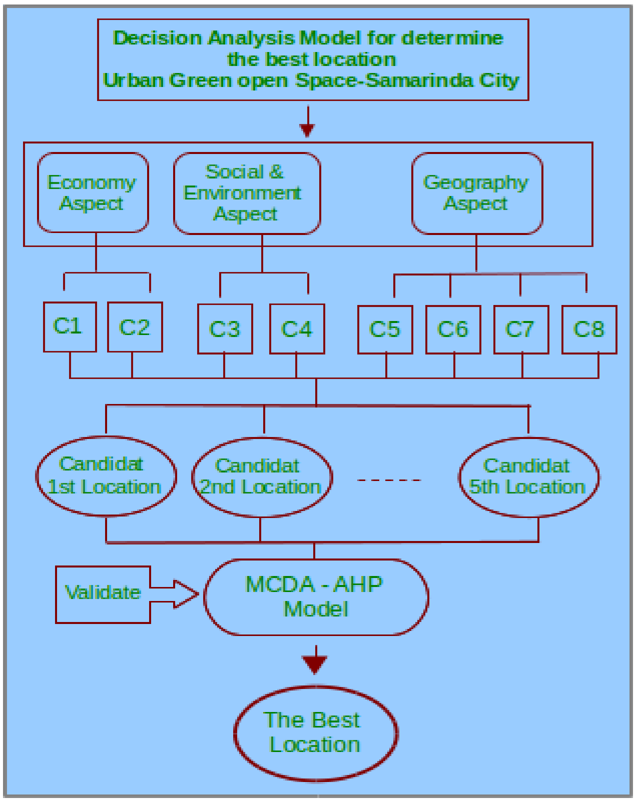


Fig. 2. Hierarchical structure of the decision model determining the best location green space in Samarinda city with MCDA AHP Model Framework think of the research

## 4 Result and Discussion

In accordance with the stages and procedures that have been developed in this study, having fixed the problem, and eight criteria for determining the best location in the green space, the next step is to set twelve of respondents who became key-persons. As for the twelve respondents, those were classified into two groups, First are policy makers about urban green space, and the 2nd group is taken from the community of users of the green space utilization. Twelve respondents are as follows :

A) Group Policy Makers

This group respondents selected as many as 6 people consisting of :

- One respondent from the Department of Cipta Karya dan Tata Kota Samarinda
- Two respondents from the Department of Kebersihan dan Pertamanan Kota
- Two respondents from the Pekerjaan Umum Department of East Kalimantan Provincial and
- one respondent from Forestry Dept. of East Kalimantan Provincial

B) User Groups

This group was chosen to be 6 respondents consisting of:

- One respondent from liability company engaged in the Environmental Impact Assessment
- One of the respondents from the banking institutions
- One of the respondents from local water companies
- Two respondents from the faculty and students of a college
- and one respondent from religious leaders in community

Twelve respondents were given the form of questions in the form of questionnaires to explore their preferences for comparison criterion green open space that has been set. The respondents were also asked to complete five candidate locations open green space in the city of Samarinda.

Based on the survey data in the field, this study has established five candidate locations open green space in the city of Samarinda, namely:

- ➔ A1: locations situated around Citra Niaga
- ➔ A2: location, situated in the center that is named ex Kaltim
- ➔ A3: locations situated around the edges of the Mahakam
- ➔ A4: locations located around Port Jl. Yos Sudarso
- ➔ A5: location Warehousing located in Jl. Ir. Sutami

Further, the accomplished analysis of the preferences of the data is obtained by using AHP method. It is using computation software, processing is done on the matrix. Table 3 and Table 4 describes the processing of pair-wise matrix, so that that it resulted in eigenvector value and a consistency ratio. Eigenvector value is the weight of each criterion as illustrated in three-dimensional graphics below.

TABEL 3
PAIRWISE MATRIX AND VALUE OF PREFERENCE

| Criteria | c1 | c2 | c3 | c4 | c5 | c6 | c7 | c8 |
|---|---|---|---|---|---|---|---|---|
| c1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| c2 | 0.5 | 1 | 2 | 2 | 1 | 1 | 1 | 2 |
| c3 | 0.5 | 0.5 | 1 | 2 | 2 | 2 | 2 | 2 |
| c4 | 0.5 | 0.5 | 0.5 | 1 | 2 | 2 | 2 | 2 |
| c5 | 0.5 | 1 | 0.5 | 0.5 | 1 | 2 | 2 | 2 |
| c6 | 0.5 | 1 | 0.5 | 0.5 | 0.5 | 1 | 2 | 2 |
| c7 | 0.5 | 1 | 0.5 | 0.5 | 0.5 | 0.5 | 1 | 2 |
| c8 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 1 |
| Sum of Column | 4.5 | 7.5 | 7.5 | 9 | 9.5 | 11 | 12.5 | 15 |

TABEL 4
VECTOR EIGEN AND CONCISTENCY RATION OF CRITERA

| Criteria | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
|---|---|---|---|---|---|---|---|---|
| Vector Eigen | 0.208 | 0.143 | 0.152 | 0.130 | 0.118 | 0.100 | 0.085 | 0.063 |
| Nilai CR | 5.6% | | | | | | | |

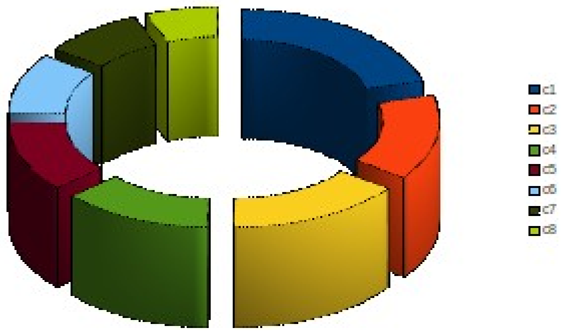


Fig. 3. Three Dimensional Graphics of Weight Criteria

Based on the eigenvalue vector, among the eight criteria, namely C1 (land area) is the criterion with the highest weight, followed by C3 (population) and then C2 (land prices) and so on. Thus, in determining the exact location for the area of green open space, then the third factor is the dominant factor and a concern to consider. In other words, the price factor is not more important than the land area and amount of people who received benefits from the existence of an open space, because of high or low land prices are very relative at a community perspective. While the distance criterion C7 and C8, has a weight the lowest, because the distance is not an issue crucial in the community during the road access, it is not as barrier.

Consistent ratio value shows a number less than 10%, it is stated that the eigenvectors generated from data analysis can be reliable for being used as a basis for decision preference for an alternative determination of the candidate locations for open space in the city of Samarinda.

Then the data analysis followed the weights of five candidate location for each criterion. This analysis has produced an eigenvector matrix of each candidate againts eight criteria as presented in Table 5. This analysis resulted in the recommendation about portion each candidate. Portion of each candidate is illustrated on Figure 4.

TABEL 5
EIGEN VECTOR VALUE FOR CANDIDATES

| Criteria | Weight | A1 | A2 | A3 | A4 | A5 | CR |
|---|---|---|---|---|---|---|---|
| C1 | 0.208 | 0.158 | 0.083 | 0.389 | 0.140 | 0.230 | 0.020 |
| C2 | 0.143 | 0.301 | 0.301 | 0.119 | 0.139 | 0.139 | 0.007 |
| C3 | 0.152 | 0.262 | 0.344 | 0.118 | 0.138 | 0.138 | 0.023 |
| C4 | 0.130 | 0.158 | 0.169 | 0.086 | 0.315 | 0.271 | 0.047 |
| C5 | 0.118 | 0.279 | 0.279 | 0.188 | 0.145 | 0.109 | 0.034 |
| C6 | 0.100 | 0.299 | 0.275 | 0.183 | 0.133 | 0.109 | 0.039 |
| C7 | 0.085 | 0.289 | 0.240 | 0.186 | 0.197 | 0.088 | 0.055 |
| C8 | 0.063 | 0.300 | 0.250 | 0.191 | 0.170 | 0.089 | 0.022 |
| Compossed Weight | | 0.243 | 0.231 | 0.196 | 0.169 | 0.161 | 1 |

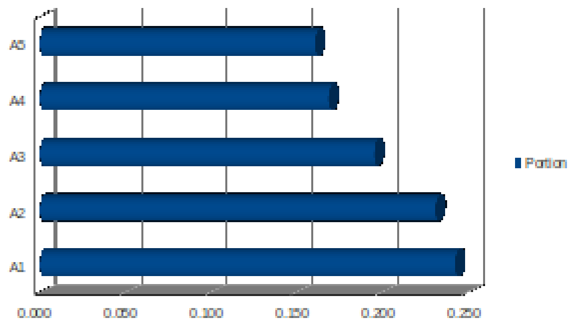


Fig. 4. Portion of Recommendation Each Candidates

Based on these tables, candidate location A1 has the highest weight followed by A2, A3, A4 and A5. Thus it can be said that the location of around Citra Niaga is the best location to serve as an area of green open space. This is because of its location in the city and meeting the requirements of all the criteria. Other areas are also good as the next candidate is ex Kaltim, Mahakam edge, port and the last is warehousing area.

Citra Niaga region is an area of the city center and a business center with high population density and the high levels of air pollution as a result of density a motor vehicles there.

This situation is the driving force that the location became the site recommended to serve as an open green area. From inspection of the table, it is also shown that the value of consistency contained no more than 10% so that the results on these models can be reliable and serve as a basis for decision masking.

## 5 CONCLUSION

This research resulted in a preliminary study of the MCDA-AHP method that can be used as a decision model for the best site selection of urban ecological space, especially GPOS in Samarinda city. Land factor is the highest criterion weight amongst the eight criteria, followed by the criteria of population and land prices. From five predetermined candidates, location of Citra Niaga is the most suitable to serve as a green public open space, followed by the Ex Kaltim, Mahakam edge, the port area and the area near to city warehouse. The analysis also provides a consistent value ratio of less than 10% so that recommendations are reliable for the given preference.

In near future, this decision model will be integrated with the software design to create a prototype model of participatory WebGIS to select best location for green public open space in Samarinda city.

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