The design of geographic information system determination of slum area to improve villages in supporting green and clean in Surabaya City using Fuzzy-AHP method

Purbandini¹, M Weridiani² and S D Puspitasari³

Information System, Faculty of Science and Technology, Airlangga University, Indonesia

Email: ¹purbandini@fst.unair.ac.id, ²melindaw@gmail.com, ³sdewipuspitasari@gmail.com

Abstract. One of the problems of an urban area is the existence of many pockets of slum area, which certainly raises many problems for the local government and the general public. Slum housing greatly affects the environment and community sanitation, as well as urban planning. To detect slum housing problems, it is necessary to have an integrated computer information system, especially one that can be used for mature planning and able to combine spatial information system and information called the Geographic Information System (GIS). This information system is equipped with Decision Support System to recommend the determination of slum areas using the Fuzzy AHP method. Fuzzy AHP is a method that is an amalgamation of Fuzzy method and AHP method. The fuzzy type used was Fuzzy Triangle Number. The fuzzy value was defined for each alternative on each criterion using the linear membership function down, ascending the triangle as an approximation to obtain the degree of membership. The output of this system is a recommendation ranking of slum locations based on predetermined criteria.

1. Introduction

Slum housing in Surabaya City often poses a problem that needs to be addressed. Many poverty alleviation programs and housing allocations, as well as provisions of assistance for slum housing, are improperly targeted. The Regional Development Planning Board (Badan Perencanaan Pembangunan Daerah) as a local government agency that regulates urban spatial planning and the referring institution for other government agencies often conduct planning, especially with regard to government policy on this issue, which is not well-targeted. The problem of inadequate facilities and infrastructure is the main reason.

To overcome this problem, spatial planning is very important. The implementation of Geographic Information System (GIS) is an appropriate step in determining which geographical areas are classified as slums. Since Geographic Information System (GIS) has spatial and temporal analysis, the technology is often used in the process of determining vulnerable regions or areas. This system also facilitates users in the determination and addressing of slum locations according to the main classification criteria using the Fuzzy-AHP method that can manage the input values in accordance with the criteria of slum areas, having certain values.
In this research, a GIS that provides information to determine the location of slum areas in support of green and clean Surabaya City was built with the purpose to build a Geographic Information System application to determine and analyze slum areas in Surabaya using the Fuzzy-AHP method.

2. Research Methods
This study used two methods, namely data processing method and system design method.
1. Data Processing Method
   The data processing method used the AHP method to produce recommendations of slum locations. The data processed were data that constitute the requirements of slum locations and alternative locations in the form of several sub-districts in Surabaya. These data were used as criteria and alternatives in data processing using the AHP method.
2. System Design Method
   The system design method used the prototype design method. Prototype is one method that can accelerate the process of system development [4]. The method involves prospective users directly in the construction of the system, so the system can be in accordance with user expectations.

3. Results and Discussion
3.1. System planning
This research described the design and implementation of geographic information systems, as well as the elaboration of hierarchical analysis results in the determination process of slum areas in Surabaya City. The development of a geographic information system was conducted through the prototype method. The system design model was the procedural model. A system design serves to get a picture of the system in general [2].
   a. System flow diagram design
   b. Context diagram design
   c. Database design
   d. Geographic Information System design
1. Tracking
   The process of coordinate collection of modern stores was done by tracking using GPS. Point determination was done in Jember City area covering three districts, namely Patrang, Sumbersari, and Kaliwates Districts.
2. Map Digitization
   Map digitization was conducted to divide the area of Jember City and mark boundaries between subdistricts, as well as to place tracking result points into the map.
3. Conversion to database
   The map digitization results were displayed in webgis. The .shp file on the map must be converted to database form. The conversion process was done by importing the .shp file into PostgreSQL.
4. AHP Analysis Results Description
   The AHP analysis provided 3 recommendations in the form of Districts. Recommendations were generated through matrix multiplication between priority weight and alternative weight.
   The design of this software system is based on data input on slum conditions. Stages in system design include the AHP process (formulating the problem, determining criteria, hierarchy design, prioritization, weighting, paired matrix, and program design as depicted by the block diagram below: Steps of the AHP analysis process:
1. Creating a Hierarchy of process structures by:
   a. Determining the problem (alternatives)
      There are several alternative location recommendations that matched the predefined criteria. Alternative slum areas in Surabaya City case study include Semampir District, Bulak District, and Kenjeran District.
b. Defining the criteria

The criteria made were details of the problem of slum area location determination based on certain factors. These criteria include:

1. The physical condition of buildings
2. Socio-economic conditions
3. Environmental sanitation conditions

The hierarchical structure consists of goals (desired aims), criteria in achieving goals, and alternatives as a result of decision recommendations of the goal.

2. Providing priority scale against criteria and alternatives.

Priority scale assessment is based on a priority rating scale table.

| Intensity of Importance | Definition               |
|--------------------------|--------------------------|
| 1                        | Equally important        |
| 3                        | Moderately more important|
| 5                        | Strongly more important  |
| 7                        | Very strongly more important|
| 9                        | Extremely more important |
| 2, 4, 6, 8               | Intermediate values      |

3. Creating a pairwise comparison matrix

The pairwise comparison matrix is a comparison between each criterion. In this comparison matrix, inverse values apply. If criterion a yields a value of x to b, then the value of criterion b to a is 1/x.
Table 2. Paired comparison matrix

| Criteria          | Environmental Sanitation | Socio-economic Issues | Physical properties |
|-------------------|--------------------------|-----------------------|---------------------|
| Environmental Sanitation | 1                        | 3                     | 2                   |
| Socio-economic Issues          | 0.5                      | 1                     | 1.5                 |
| Physical properties              | 0.33                     | 0.66                  | 1                   |
| Total                   | 1.83                     | 4.66                  | 4.5                 |

4. Calculating the priority weight
Priority Weight is the weight used in the matrix multiplication process to generate recommendations. The steps in obtaining priority weight include:
Summing the values in one column and doing it for each column. The results of the calculation are as follows.

Table 3. Criteria Weight

| Criteria          | Vector Average |
|-------------------|----------------|
| Environmental Sanitation | 0.544889785   |
| Socio-economic Issues          | 0.273716551   |
| Physical properties              | 0.181393664   |

Table 4. Criteria weights of physical condition for each alternative

| Physical condition | Vector Average |
|--------------------|----------------|
| Kec. Semampir  | 0.251705653    |
| Kec. Bulak       | 0.490253411    |
| Kec. Kenjeran    | 0.258040936    |

Table 5. Criteria weights of socio-economic conditions for each alternative

| Socio-economic conditions | Vector Average |
|---------------------------|----------------|
| Kec. Semampir  | 0.368927369    |
| Kec. Bulak       | 0.286676287    |
| Kec. Kenjeran    | 0.344396344    |

Table 6. Criteria weights of environmental sanitation conditions for each alternative

| Sanitation Conditions | Vector Average |
|-----------------------|----------------|
| Kec. Semampir  | 0.293638409    |
| Kec. Bulak       | 0.388204098    |
| Kec. Kenjeran    | 0.318157493    |
5. Calculating alternative weight

Alternative weight is the weight used in the matrix multiplication process to generate recommendations. The multiplication of the matrix is the multiplication of the alternative weight and the criterion weight. Alternative weight was obtained through the following calculation.

a. Calculating the weight as in the priority weight calculation.

b. Calculating composite weight (CW)

The calculation of CW is done by multiplying the priority weight of the alternative with the priority weight of the criterion. The result that has the highest recommendation is the largest CW value. Thus, the results of the analysis are as follows.

| Alternative       | Criteria Weight | Semampir District | Bulak District | Kenjeran District |
|-------------------|-----------------|-------------------|----------------|-------------------|
| Semampir District | 0.5448          | 0.2517            | 0.4902         | 0.2580            |
| Bulak District    | 0.2737          | 0.3689            | 0.2867         | 0.3443            |
| Kenjeran District | 0.1814          | 0.2937            | 0.3882         | 0.3182            |
| Total CW          |                 | 0.2913            | 0.4161         | 0.2925            |

Based on the table of alternative weights above, it can be concluded that the highest score is for Bulak District with a score of 0.4161, while the second highest is for Kenjeran District with a score of 0.2925, followed by Semampir District with a score of 0.2913.

The location view of the slum area selection in some districts in Surabaya City are based on Fuzzy AHP calculations.

![Figure 3. The location view of slum area selection](image)

Notes:
- : selected alternative (Bulak)
- : available alternatives

4. Conclusion

The following conclusions can be drawn:

1. Geographic Information System can map the spread of slum areas of Surabaya City
2. Geographic Information System can be used as a decision support system in determining the location of slum areas.
3. Recommendation results depend on the criteria and alternative consistency values. The ranking on the priority criteria greatly affects the outcome. If the difference range between one criteria and another is greater, then the results of the calculation with the AHP Fuzzy method will also be very different and the degree of dominance of each criterion will be different depending on the size of the priority.

4. The most preferred recommendation result is the Bulak District.

References

[1] Puntodewo A, Dewi S, dan Tarigan J. 2003. *Sistem Informasi Geografis Untuk Pengelolaan Sumber data Alam*. Bogor Barat: Center for International Forestry Research.

[2] JMcLeod, Raymond, George, P. Schell. 2008. *Management Information Systems Sistem Informasi Manajemen edisi 10*. Jakarta : Salemba empat.

[3] L. Saaty, Thomas, 1993, *Pengambilan keputusan bagi para pemimpin*, PT Pustaka Binaman Pressindo.

[4] Marimin, ddk. 2006. *Sistem Informasi manajemen Sumber Daya Manusia*. Bogor: Grasindo.

[5] Vera, Ridha. 2009. *Pendekatan Model Fuzzy Goal Programming Dalam Penetapan Pembobotan Prioritas Dari Metode Analytical Hierarchy Process (AHP)*, Universitas Sumatra Utara Medan : Medan.

[6] http://digilib.its.ac.id/public/TTS-paper-23818-3508100039-Paper.pdf diakses tanggal 15 Juni 2013, pukul 11:27

[7] http://elib.unikom.ac.id/download.php?id=481 diakses tanggal 15 Juni 2013 pukul 11:25

[8] http://id.wikipedia.org/wiki/Semampir,_Surabaya diakses tanggal 23 Juni 2013 pukul 13:45

[9] http://fenomena perkampungan kumuh di tengah perkotaan faktor penyebab, dampak dan upaya mengatasi « z.a.k.i.a_k.d.htm diakses tanggal 15 Juni 2013 pukul 11:4

[10] makalah-permukiman-kumuh-dan-upaya.html diakses tanggal 23 Juni 2013 pukul 13:45