Determination of the Priority Aspect in Process of Determining Urban Residential Area

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Abstract. Recently, the population growth is increasingly crowded in urban area and as a source of land supply for housing development into the needs of each individual becomes increasingly limited. the home is one of the basic rights of the people and therefore every citizen has the right to reside and got a good environment and healthy. Besides the house is also a basic human need to enhance the dignity, the dignity, quality of life and livelihood, as well as personal self-reflection in order to improve the standard of living, as well as the formation of character, character and personality of the nation. The construction of such housing should always take into consideration many aspects in order to create a balanced environment not only based on the suitability of land but also based on the aspects that exist in surrounding. Therefore, this study will be to analyze the priority aspect in process of determining urban residential area using Analytical Hierarchy Process Method. This method aims to determine priority aspect were used based on primary data collection form of questionnaires and interviews to respondents who expert in the field.

Keywords : Aspect, AHP, Urban Area, Residential Area

1. Background
Population growth is increasingly crowded in urban area every time especially in major city in Indonesia such as Surabaya. It plays important rule as a source of land supply for residential area development into the needs of each individual becomes increasingly limited. Residential area is the one of the basic rights of the people, therefore every citizen has the right to reside and got a good environment and healthy. Besides the house is also a basic human need to enhance the dignity, the dignity, quality of life and livelihood, as well as personal self-reflection in order to improve the standard of living, as well as the formation of character, character and personality of the nation. The construction of such housing should always take into consideration many aspects in order to create a balanced environment not only based on the suitability of land but also based on the aspects that exist in surrounding. The transformation of land use in urban areas is often carried out in order to meet the housing needs for people are increasing. Residential area development should meet the basic requirements for urban development such as accessibility, compatibility, flexibility, and ecology. The designated residential area is an area intended for residential or residential environments and places of activity which can support the life and livelihoods [1]. The construction of such housing should always take into consideration environmental aspects and development sites in accordance with the spatial plan to create a balanced environment and
the provision of facilities and infrastructure necessary to develop an efficient and integrated way, directed, planned and ongoing / continuous.

Therefore, this study will be to analyze the priority aspect in process of determining urban residential area using Analytical Hierarchy Process Method. This method aims to determine priority aspect were used based on primary data collection form of questionnaires and interviews to respondents who expert in the field.

2. Methodology

2.1. Study Area

Study area for this study is located in West Surabaya, Surabaya city, East Java, Indonesia with geographical location being on 7°13’22”,238 south latitude - 7°14’44”,476 south latitude and 112°35’29”,605 east longitude - 112°43’3”,973 east longitude.

2.2. Data Processing

In making policy on the determination of the location of residential area development, we used three criteria in this study such as criteria of social, economy, and accessibility. The factors which influence the determination of the location of residential area development used as sub-criteria, where the similar subcriteria were grouped in the same criteria. The Analytical Hierarchy Process (AHP) method aims to determine the priority level of the alternative location of residential area development by determining the weighting of each criterion and subcriterion[2]. The value of the priority scale used in this study was derived from primary data collection in the form of questionnaires and interviews to some respondents who are experts in social, economics, accessibility, population, education facilities, employment, land / building price, population income, transportation, electricity network, and water distribution at Lakarsantri, Sukomanunggal, and Sambikerep.

There were some steps in processing data. First, to obtain the priority scale value which will be used for pairwise comparison matrix, then for the criteria and subcriteria priority scale were calculated geometric averages to level out the pairwise results because the assessment involves more than one person. Key informants are members who reflect the interests of people who know a lot about the culture, are able and willing to share their knowledge [6]. Geometric averages are calculated using the following equation:

\[ G = \sqrt[n]{X_1 \cdot X_2 \cdot X_3 \ldots \ldots \ldots \cdot X_n} \]  

Where,

- \( G \) = geometric average
- \( X_1, X_2, \ldots, X_n \) = assessment to-1,2,.........,n
- \( n \) = number of assessment

Second, these priority scale results as a pairwise comparison matrix of criteria and sub criteria, then normalized to standardize every element of eigenvector. So, we can get the priority weight of each criterion and sub criteria. Before normalizing in pairwise comparison matrix, the columns of each criterion/sub criteria are summed to use as a calculation in the next step by using the following equation:

\[ S_j = \sum_{i=1}^{n} a_{ij} \]  

Where,

- \( S_j \) = Total Value of Each Column
- \( a_{ij} \) = Matrix i to j
- \( n \) = Number of Criterion [3]

Normalizing in pairwise comparison matrix were calculated by using the following equation:

\[ V_{ij} = \frac{a_{ij}}{S_j} \]  

(3)
Where,
\( V_{ij} = \text{Normalized Value of Matric I to j} \)
\( S_j = \text{Total Value of Each Column} \)
\( a_{ij} = \text{Matrix i to j} \) [3]

The priority weight of each criterion was obtained from summation of each line of the normalization of pairwise comparison matrix, then it was divided by the number of criterion as in the following equation:

\[
w_i = \frac{\sum_{j=1}^{n} V_{ij}}{n}
\]  \hspace{1cm} (4)

Where,
\( W_{ij} = \text{Priority Weight} \)
\( V_{ij} = \text{Normalized Value of Matric i to j} \)
\( n = \text{Number of Criterion} \) [4]

The maximum eigen value (\( \lambda_{max} \)) was calculated to measure the consistency of a matrix by using the following equation:

\[
\lambda_{max} = \frac{1}{n} \sum_{i=1}^{n} \frac{[A^w]_i}{w_i}
\]  \hspace{1cm} (5)

Where,
\( \Lambda_{max} = \text{Maximum Eigen Value} \)
\( A = \text{Eigenvalue} \)
\( w_i = \text{Priority Weight} \)
\( n = \text{Number of Criterion} \) [4]

The consistency index (CI) aims to provide information about logical consistency of pairwise comparison. When CI = 0.0, there were a logical inconsistency between pairwise comparison, or the assessment was considered 100% consistent.

After maximum eigen value (\( \lambda_{max} \)) was obtained, then consistency index value calculated by using the following equation:

\[
CI = \frac{\lambda_{max}-n}{n-1}
\]  \hspace{1cm} (6)

Where,
\( CI = \text{Consistency Index} \)
\( \lambda_{max} = \text{Maximum Eigen Value} \)
\( n = \text{Number of Criterion} \) [5]

The Consistency Ratio (CR) aims to measure how a consistent assessment relative to a large sample of random purely assessments. After the consistency index value (CI) was obtained, then the value of consistency ratio calculated by using the following equation:

\[
CR = \frac{CI}{RI}
\]  \hspace{1cm} (7)

Where,
\( CI = \text{Consistency Index} \)
\( CR = \text{Consistency Ratio} \)
\( RI = \text{Random Index} \)
3. Results and Discussion
The weighting factor calculation is performed on each criterion and sub-criteria as follows:

3.1. Criteria
Primary data / quantitative data obtained from eight respondents to the assessment among criteria first calculated average by using geometric mean that aims to flatten the results of pairwise comparisons. The results of the priority scale of the questionnaire of respondents as well as the results of the calculation of geometric mean is contained in the following table.

| District                  | Social-Economic | Social-Accessibility | Economic-Accessibility |
|---------------------------|-----------------|----------------------|------------------------|
| Lakarsantri District      | 1/6             | 5                    | 1                      |
| Lidah wetan Subdistrict   | 7               | 5                    | 1/5                    |
| Sambikerep District       | 1/5             | 1/9                  | 1/7                    |
| Lontar Subdistrict        | 4               | 1                    | 3                      |
| Sambikerep Subdistrict    | 1/3             | 1/5                  | 1/3                    |
| Sukomanunggal District    | 4               | 1/5                  | 5                      |
| Sonokwijenan Subdistrict  | 1               | 5                    | 5                      |
| Sukomanunggal Subdistrict | 1/7             | 1/9                  | 1/9                    |
| **Average Geometric**     | **0.80581**     | **0.70601**          | **0.72854**            |

Based on Table 1, the average geometric value between social to economic criteria amount 0.80581, among social to accessibility criteria amount 0.70601, and between economic criteria against accessibility criteria of 0.72854. The geometric value of the value $a_{ij} = 1$ for $i = j$, pairwise comparison matrix can be seen in the following table.

| Criteria        | Social | Economic | Accessibility |
|-----------------|--------|----------|---------------|
| Social          | 1      | 0.80581  | 0.70601       |
| Economic        | 1.24098 | 1        | 0.72854       |
| Accessibility   | 1.41641 | 1.37261 | 1             |
| **Total**       | 3.65739 | 3.17842 | 2.43455       |

Based on Table 2, total value of each criteria shows the total value on the social criteria amount 3.65739, economic criteria amount 3.17842, and accessibility criteria amount 2.43455. Then the normalization of pairwise comparison matrix which aims to determine the relative importance of the various criteria computed was calculated using the formula in equation 3. Normalization of pairwise comparison matrix can be seen in the following table.

| Criteria        | Social | Economic | Accessibility |
|-----------------|--------|----------|---------------|
| Social          | 0.27342 | 0.25353 | 0.29000       |
| Economic        | 0.33931 | 0.31462 | 0.29925       |
| Accessibility   | 0.38727 | 0.43185 | 0.41075       |
| **Total**       | 1      | 1        | 1             |
To obtain the priority weight of each criteria, the result of normalization was calculated using the formula in equation 4. So, the priority weight of each criterion can be seen in the following table.

| Criteria        | Total     | Weight  | Priority |
|-----------------|-----------|---------|----------|
| Social          | 0.81694   | 0.27231 | 3        |
| Economic        | 0.95318   | 0.31773 | 2        |
| Accessibility   | 1.22988   | 0.40996 | 1        |
| Total           | 3         | 1       |          |

Based on table 4, the priority of each criteria used in the process of determining the location of residential area development in West Surabaya were dominated by the highest accessibility criteria amount 0.40996. The weight of the obtained must be determined the ratio of consistency of the opinions of various respondents in this study to measure the quality of priority vector, if the value of consistency ratio less than 0.1, the opinion of respondents which were considered inconsistent were acceptable. Whereas, if the value of consistency ratio is more than 0.1, the opinion of the respondent which were considered inconsistent were not acceptable and must be done by taking re-questionnaire to determine the weight so that the value of consistency ratio is in accordance with the specified. Eigenvalue maximal ($\lambda_{max}$) in these criteria amount 3.00378. Consistent index (CI) in these criteria amount 0.00189. Ratio of consistency (CR) in these criteria amount 0.00326.

3.2. Social Criteria

The results of the priority scale of the results of questionnaires of respondents as well as the results of the calculation of average geometric mean were contained in the following table.

| District               | Population-Educational | Population - Health Facility | Educational - Health Facility |
|------------------------|------------------------|------------------------------|-------------------------------|
| Lakarsantri District   | 1                      | 1                            | 1                             |
| Lidah wetan Subdistrict| 5                      | 7                            | 3                             |
| Sambikerep District    | 1                      | 3                            | 3                             |
| Lontar Subdistrict     | 7                      | 4                            | 1/9                           |
| Sambikerep Subdistrict | 3                      | 1/5                          | 1/5                           |
| Sukomanunggal District | 3                      | 3                            | 1                             |
| Sonokwijenan Subdistrict| 1                    | 1/5                          | 1                             |
| Sukomanunggal Subdistrict | 1/81              | 1/6                          | 9                             |
| **Average Geometric**  | **1.58271**            | **1.06700**                  | **1.07624**                   |

Based on Table 5, the average geometric value between sub criteria of population condition to educational amount 1.58271, Pairwise comparison matrix can be seen in the following table.
Table 6. Pairwise comparison matrix of social sub criteria

| Subcriteria      | Population | Educational | Health Facility |
|------------------|------------|-------------|-----------------|
| Population       | 1          | 1.58271     | 1.06700         |
| Educational      | 0.63183    | 1           | 1.07624         |
| Health Facility  | 0.93721    | 0.92916     | 1               |
| **Total**        | **2.56903**| **3.51188** | **3.14324**     |

Based on Table 6, total value of each sub criteria shows that total value in the sub criteria of population amount 2.56903, sub criteria of educational facility amount 3.51188, and sub criteria of educational facility amount 3.14324. Normalization of pairwise comparison matrix can be seen in the following table.

Table 7. Normalization of pairwise comparison matrix of social sub criteria

| Subcriteria      | Population | Educational | Health Facility |
|------------------|------------|-------------|-----------------|
| Population       | 0.38925    | 0.45068     | 0.33946         |
| Educational      | 0.24594    | 0.28475     | 0.34240         |
| Health Facility  | 0.36481    | 0.26458     | 0.31814         |
| **Total**        | **1**      | **1**       | **1**           |

Table 8. Weight of subcriteria social priority

| Sub criteria      | Total  | Weight | Priority |
|-------------------|--------|--------|----------|
| Population        | 1.17938| 0.39313| 1        |
| Educational       | 0.87309| 0.29103| 3        |
| Health Facility   | 0.94753| 0.31584| 2        |
| **Total**         | **3**  | **1**  |          |

Based on Table 8, the priority of each sub criteria in the social criteria used in the process of determining the location of residential area in West Surabaya were dominated by the population sub criteria amount 0.3931. Eigenvalue maximal (λmax) in this sub criteria amount 3.02479. Consistent index (CI) in these criteria amount 0.01239. Ratio of consistency (CR) in these criteria amount 0.02137.

3.3. Economic Sub criteria
The results of the priority scale of the results of questionnaires of respondents as well as the results of the calculation of average geometric mean were contained in the following table.
Table 9. Average geometric economic sub criteria

| District                  | Labor-Land Value | Labor-Income Level | Land Value – Income Level |
|--------------------------|------------------|--------------------|--------------------------|
| Lakarsantri District     | 2                | 9                  | 2                        |
| Lidah wetan Subdistrict  | 1/9              | 7                  | 9                        |
| Sambikerep District      | 0.2              | 1/3                | 3                        |
| Lontar Subdistrict       | 1/3              | 5                  | 1                        |
| Sambikerep Subdistrict   | 7                | 1/7                | 1/7                      |
| Sukomanunggal District   | 7                | 1                  | 3                        |
| Sonokwijenan Subdistrict | 9                | 1                  | 0.2                      |
| Sukomanunggal Subdistrict| 1/9              | 1/9                | 9                        |
| **Average Geometric**    | 0.96075          | 1.06594            | 1.59390                  |

Based on Table 9, the average geometric value between sub criteria of labor to land value amount 0.96075, between sub criteria of labor to income level amount 1.06594, and sub criteria of land value to income level amount 1.59390. Pairwise comparison matrix can be seen in the following table.

Table 10. Pairwise comparison matrix of economic sub criteria

| sub criteria    | Labor | Land Value | Income Level |
|-----------------|-------|------------|--------------|
| Labor           | 1     | 0.96075    | 1.06594      |
| Land Value      | 1.04085 | 1          | 1.59390      |
| Income Level    | 0.93814 | 0.62739 | 1            |
| **Total**       | 2.97899 | 2.58814 | 3.65984      |

Based on Table 10, total value of each sub criteria shows that total value of the sub criteria of labor amount 2.97899, the sub criteria of land value amount 2.58814, and sub criteria of income level amount 3.65984. Normalization of pairwise comparison matrix can be seen in the following table.

Table 11. Normalization of pairwise comparison matrix of economic sub criteria

| sub criteria    | Labor | Land Value | Income Level |
|-----------------|-------|------------|--------------|
| Labor           | 0.33568 | 0.37121 | 0.29125      |
| Land Value      | 0.34940 | 0.38638 | 0.43551      |
| Income Level    | 0.31492 | 0.24241 | 0.27324      |
| **Total**       | 1      | 1          | 1            |

Table 12. Weight of economic sub criteria priority

| sub criteria    | Total   | Weight  | Priority |
|-----------------|---------|---------|----------|
| Labor           | 0.99815 | 0.33272 | 2        |
| Land Value      | 1.17129 | 0.39043 | 1        |
| Income Level    | 0.83057 | 0.27686 | 3        |
| **Total**       | 3       | 1       |          |

Based on Table 12, the major priority of each sub criteria in the economic criteria used in the process of determining the location of residential area development in West Surabaya highest dominated by sub
criteria of land value amount 0.39043. Eigenvalue maximal ($\lambda_{max}$) in this sub criteria amount 3.01489. Consistent index (CI) in these criteria amount 0.00744. Ratio of consistency (CR) in these criteria amount 0.01284.

3.4. **Accessibility sub criteria**

The results of the priority scale of the results of questionnaires of respondents as well as the results of the calculation of average geometric were contained in the following table.

**Table 13. Average geometric accessibility sub criteria**

| District                  | Public Transportation -Electric Network | Public Transportation -Water Distribution | Electric Network - Water Distribution |
|---------------------------|----------------------------------------|-------------------------------------------|--------------------------------------|
| Lakarsantri District      | 1                                      | 1                                         | 1                                    |
| Lidah wetan Subdistrict   | 7                                      | 1                                         | 7                                    |
| Sambikerep District       | 1/3                                    | 3                                         | 5                                    |
| Lontar Subdistrict        | 1                                      | 1                                         | 1                                    |
| Sambikerep Subdistrict    | 7                                      | 7                                         | 1/7                                  |
| Sukomanunggal District    | 7                                      | 1                                         | 1/6                                  |
| Sonokwijenan Subdistrict  | 1                                      | 1                                         | 3                                    |
| Sukomanunggal Subdistrict | 1/9                                    | 9                                         | 9                                    |
| **Average Geometric**     | **1.37401**                            | **1.92556**                               | **1.47578**                          |

Based on Table 13, the average geometric value between sub criteria of public transportation to electric network amount 1.37401, between sub criteria of public transportation to water distribution amount 1.92556, and between sub criteria of electric network to water distribution amount 1.47578. Pairwise comparison matrix can be seen in the following table.

**Table 14. Pairwise comparison matrix of accessibility sub criteria**

| sub criteria     | Public Transportation | Electric Network | Water Distribution |
|------------------|-----------------------|------------------|--------------------|
| Public Transportation | 1                     | 1.37401          | 1.92556            |
| Electric Network  | 0.72779               | 1                | 1.47578            |
| Water Distribution| 0.51933               | 0.67761          | 1                  |
| **Total**        | **2.24712**           | **3.05162**      | **4.40135**        |

Based on Table 14, the total value of each sub criteria shows that total value of the sub criteria of public transportation amount 2.24712, the sub criteria of electric network amount 3.05162, and the sub criteria of water distribution amount 4.40135. Normalization of pairwise comparison matrix can be seen in the following table.

**Table 15. Normalization of pairwise comparison matrix of accessibility sub criteria**

| sub criteria     | Public Transportation | Electric Network | Water Distribution |
|------------------|-----------------------|------------------|--------------------|
| Public Transportation | 0.44501               | 0.45026          | 0.43749            |
| Electric Network  | 0.32388               | 0.32769          | 0.33530            |
| Water Distribution| 0.23111               | 0.22205          | 0.22720            |
| **Total**        | **1**                 | **1**            | **1**              |
Table 16. Weight of accessibility sub criteria priority

| sub criteria       | Total  | Weight   | Priority |
|--------------------|--------|----------|----------|
| Public Transportation | 1.33276 | 0.44425  | 1        |
| Electric Network   | 0.98688 | 0.32896  | 2        |
| Water Distribution | 0.68036 | 0.22679  | 3        |
| Total              | 3      | 1        |

Based on Table 16, the priority of each sub criteria in accessibility criteria used in the process of determining the location of residential area development in West Surabaya highest dominated by public transportation sub criteria amount 0.44425. Eigenvalue maximal ($\lambda_{\text{max}}$) in this sub criteria amount 3.00378. Consistent index ($CI$) in these criteria amount 0.00189. Ratio of consistency ($CR$) in this criteria amount 0.00326.

4. Conclusion

The result for this research indicate that the priority aspect of each criteria used in the process of determining the location of residential area development in West Surabaya were dominated by the highest accessibility criteria amount 0.40996. The other hand, we used economic criteria as the second priority aspect with the weight amount 0.31773, and the third priority was the social criterion with the weight amount 0.27231.

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