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Strategy of the policy of sustainable housing development using AHP method at the village Ihamahu-Maluku, Indonesia

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Abstract

This paper focuses on the application of analytic hierarchy process (AHP) as a potential method in the context of sustainable development in housing construction in the village Ihamahu village at Maluku province, Indonesia. Election issues, sustainable housing development policy is used as an example. Some criteria such as social dimension, economy dimension, and a dimension environment used to build a hierarchical structure. In addition, sub-criteria consist of several dimensions in order to give a more detailed explanation of the problems encountered. Through the application of AHP method, criteria and sub-criteria can be prioritized and alternative made within the framework of the election the best policy alternative in sustainable residential development. Questionnaires to five key informants in the village Ihamahu used to obtain information on the factors and criteria related to alternative issues. The study found that the preference policy of housing development is the highest priority (0.602), environmental policy preferences (0.275) and the lowest priority is education policy (0.123). In addition, the study also found that the consistency of the respondents 0.04 <0.10. The study also expresses the sensitivity performance of each decision alternative. Thus, it is expected that stakeholders can apply AHP in determining preferences in decision making in the future.

Keywords: Analytic Hierarchy Process, AHP, Sustainable development, housing, Ihamahu-Maluku

INTRODUCTION

Humans and the environment are the two components are inseparable and mutually supportive in supporting the sustainable development process. This condition makes the human attention to the preservation and support of the environment becomes very important. This is because it is consistently good nature should be preserved in order to defend the interests of human organisms and future generations. One of the basic necessities of human life is a residence or home. Furthermore, in most of the world's population carry out activities at home (Semeraro and Fregonara, 2013. For example, the social interaction between family members and neighbors (Olewnik and Lewis, 2008).

The UN reported that population growth grows around 1.6 billion in 1900 to approximately 6.1 billion persons in 2000 (UN, 2001). This makes the twentieth century as the century of the population explosion that is unprecedented. Thus, this gives a significant impact on economic development and environmental change. World population growth over the last few centuries encourages environmental damage such as air pollution, climate change, plants and animal habitat loss and depletion of natural resources. As one of the strengths that exist in nature, population growth showed significant correlation. It is characterized by the use of more resources and the destruction of the earth by the waste. Furthermore, there is a concern with the declining capacity of ecosystems for future generations in the past few years. For example, water supply and water, flood control, conservation and regeneration of soil, and biodiversity. (IPCC, 2001; Daily, 1997)

Environmental crises that have concerned people concerned about the environment since the late 20th century, however, in 1972 established a new international meeting on the environment in Stockholm initiated by the United Nations. In addition, as one of the efforts to determine the correlation between the issues of economic development and environmental stability, hence at around 1987 Brundtland Commission made a report entitled Our Common Future. The report is often referred because it gives a definition of the concept of sustainable development. The concept of sustainable development explained that the development should pay attention to generation in the future, especially related to the resources used (United Nations General Assembly, 1987, p. 43). Nurture economic growth and protect the environment is the goal of the concept of sustainable development.

In the past, many traditional villages and forming neighborhoods grew naturally through non-governmental. By always applying the local knowledge possessed, the sustainability of a traditional village very dependent on the condition of the natural surroundings in which people live. Currently, many settlements are planned and built by the government, especially for low-income people in urban areas as a new community. Settlements built by the government still require quality housing to the process of sustainable development. Chan & Lee, (2006) describes the development policies in many countries is a common goal of sustainable development. The presence of a global goal of sustainable development to encourage the construction of environmentally friendly housing has increased significantly in all countries in the world in recent decades. Studies conducted by Randolph et al., (2008) underlines that the focus of sustainable housing is the application of several factors such as physical principles, design, methods, and materials used. In addition, several factors that also should be considered in the sustainable housing such as assurance of public health, the level of productivity and environmental impact (Nazirah, 2005).

Obviously, there are several criteria that may be considered in decision-making regarding the provision of sustainable housing, for example, at affordable prices, the impact of housing on the environment, socioeconomic (Maliene *et al.* 2008). This paper aims to assess the potential criteria for sustainable housing development in the Ihamahu village at Maluku province, Indonesia. It also relates to the application of Analytical Hierarchy Process (AHP) in the process of the selection criteria for sustainable housing development. Selection criteria and the decision of several alternatives, sustainable housing developments is a complicated process. This process requires the evaluation of several criteria and alternatives are interlinked. The analysis process will evaluate the criteria and alternatives considered appropriate sustainable housing development.

LITERATURE REVIEW

Sustainable development issues are the increasingly complex environment, especially in a difficult economic situation, the decision-making regarding the appropriate sustainable development will have important implications for the development of an area in the future. Selection of appropriate solution which is considered a challenging situation the decision makers in making decisions. In addition, there are several factors to determine that scientific decision-making processes, such as problem identification, data collection, use of scientific methods in the analysis and the decision alternatives will be chosen in an objective decision-makers (Landaeta, 2005).

Generally, there are several factors faced by decision makers, for instance, complex systems associated with the use of resources, targets to be achieved, a result which might arise from the decision-making (Saaty, 1980). Thus, Stay proposed AHP as one of the alternatives the completion of the selection criteria in decision making (Saaty, 1980). Furthermore, the decision-making hierarchy is determined through the development of sub-problems that are then analyzed by comparing the sub-problems alternately (Attaran and Celik, 2013). In addition, the AHP method provides an overview of complex decision making based workflow through rationality complex problem settings systematically. Saaty also explained that the AHP method is more profitable than other decision-making methods. This is due to the consistent and rational comparison of the conversion of a numerical weighting of diverse elements (Saaty, 2008).

AHP has been widely used by researchers in the field of environment, for example, site selection limestone quarry in Barbados (Dey and Ramcharan, 2008), the selection of the landfill site (Sener et al., 2006), the site selection of transshipment (Oenuet and Soner (2008), the management of electronic waste in Surabaya (Rimantho et al., 2014), the decision-making in the selection of the best end of life actuation computer (Ravi et al., 2005), Choose the method of analysis of organic substances (Rimantho et al., 2016), decision-making prevention of work accidents on garbage collecting workers (Rimantho and Cahyadi, 2016), making the priority hierarchy of problem structures on the calibration of equipment in the pharmaceutical industry (Rimantho et al., 2017). AHP is one method of effective decision-making, especially when there is subjectivity in the problem (Tuzmen and Sipahi, 2011). Thus, the need to build a hierarchy and sub-hierarchy of criteria and sub-criteria. The process is summarized in figure 1.

Studies conducted by Morrissey and Browne (2004) highlighted the various benefits that may be obtained from the application of AHP as the method of selecting criteria in decision-making, for instance, the evaluation of policy options and understanding of the issues can be made possible by a systematic approach, the use of quantitative and qualitative information. On the contrary, there are several notes that must be considered in the application of AHP, such subjectivity in the allocation of weights to each criterion as well as alternatives (Morrissey and Browne, 2004. This is because the weight gave a personal assessment of the preferences of the experience of stakeholders in the decision-making that may contravene (Qureshi et al, 1999). Thus, the weight changes can potentially generate a different decision (Dyer, 1990).

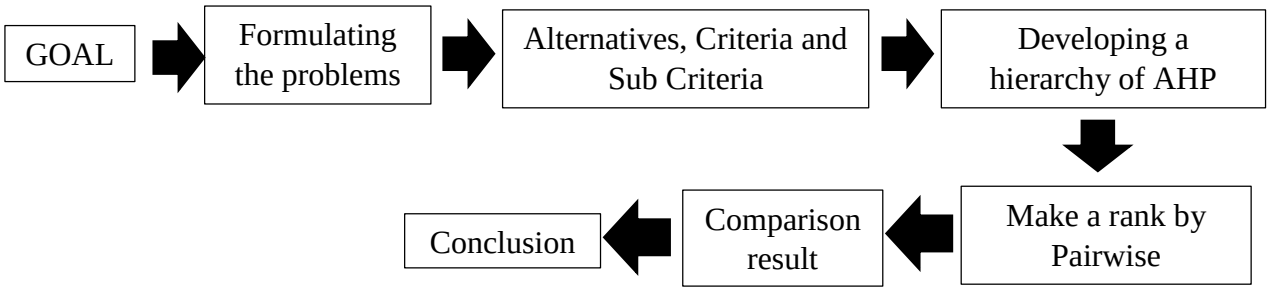

Figure 1. The process of AHP model

In order to assist give an assessment in decision-making, hence the ratio of the scale and the relative importance of the criteria have been developed. The scale is meant here is the value in the range of 1 to 9. Then, assigning weights to the value by comparing among the criteria contained in the matrix. This comparison matrix will be the main determination in the subsequent calculations (Sharma, et al., 2008). The scale that will be used in the assessment of the comparison matrix as the table 1 below.

Table 1. Pairwise comparison scale (Saaty, 1980)

Intensity of importance	Explanation
1	Two criteria contribute equally to the objective
3	Experience and judgment slightly favor one over another
5	Experience and judgment strongly favor one over another
7	The criterion is strongly favored and its dominance is demonstrated in practice
9	The importance of one over another affirmed on the highest possible order
2, 4, 6, 8	Used to represent a compromise between the priorities listed above

Generally, the AHP method consists of several steps such as setting goals, formulating the problem, alternatives and criteria set, build a hierarchical model, comparing the matrix in pairs, and issue a decision. However, decisions with the AHP model can be done by applying three steps specifically. Step 1: build a matrix of pairwise comparisons based on the hierarchical structure of the criteria, sub-criteria, and alternatives at every level. Calculation of the relative weighting of each criterion and sub-criteria using formulations eigenvectors as the formula below:

$$A = (a_{ij})_{nxn} = \begin{pmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ - & - & \dots & - \\ - & - & \dots & - \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{pmatrix} \quad (1)$$

Step 2: The maximum Eigenvectors and eigenvalues are calculated. At this stage, every matrix normalized and calculate the relative weights, wherein, the relative weighting is the result of the multiplication of the eigenvector (w) and the largest eigenvalue (λmax). The formula is as follows:

$$Aw = \lambda_{max} \text{ x } w \quad (2)$$

Step 3: Measurements of consistency

This step is performed to determine the difference λmax, and measure the consistency of assessment experts in pairwise comparisons. Consistency assessment matrix can be performed with a consistency index (CI) and the consistency ratio (CR) as shown in Equation (3) and (4), wherein is recommended for CR values around 0.1. Furthermore, Borajee and Yakchali (2011), suggest repeating the evaluation of the consistency of the final assessment if the ratio exceeds the value of 0.1 in order to obtain good consistency. A calculated consistency index (CI) using the following formula:

$$CR = \frac{CI}{RI} \qquad (4)$$

Table 2. Random Index (Saaty, 1980)

n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

METHODOLOGY

Decision making related to the development of sustainable housing has integrated several criteria that include the dimension of environmental protection, economic dimension, and the social dimension. Every criterion can be composed of several problems such as social relationships, security and comfortable, access to education, access to environment and health, access to natural resources. Furthermore, the economic dimension criteria consist of employment, technology, and telecommunication. In addition, the dimension of environmental protection may consist of green space, air quality, clean water, wastewater, solid waste and environment conservation. Thus, the development of sustainable housing is an issue that consists of a variety of complex criteria. It is very appropriate to apply the method of AHP on this issue. AHP method can be implemented in order to measure a priority in several alternatives with the scale ratio based on the judgment and experience of experts.

This study used a questionnaire involving key informants from different backgrounds with the assumption that these respondents had experience associated with this research, such as academics, community leaders, government and relevant stakeholders. Simple random sampling strategy used to determine the amount of the sample population of respondents. Thus, each member of the population has an equal chance to be key informants in this study. By using a confidence level of 95%, 5% and the proportion of the population of 20 percentage points absolute precision obtained a number of key informants about five people (Lwanga and Lemeshow, 1991).

Respondents will be given a questionnaire in order to obtain a score pairwise comparisons between factors based on AHP method. This will help in making the pairwise matrix in determining the weight of each criterion, sub-criteria, and alternatives. The relative importance of using the Saaty scale of 1-9 depending assessment of each key informants. Based on these metrics, calculation by giving each of the weights and calculate the consistency ratio. The procedure of calculation and assigning weights to each criterion and sub-criteria is done repeatedly until comparing each alternative. The processing of the data is processed using the Expert Choice software. This program is one program that can assist in the calculation method of AHP. Through this tool can perform sensitivity analysis, printing charts, and calculation tables.

RESULT

The AHP method makes it easy for every member of the group of respondents to use the experience, values, and knowledge to solve problems in making decisions. Thus the preparation of the hierarchy and completion of the problem will be more focused and directed. Through brainstorming either by questionnaires or interviews will be easier to explore the understanding of the problems of sustainable residential development.

Table 3. Preferences on sustainable development housing policy

GOAL	Alternatives	Criteria	Sub Criteria	
SUSTAINABLE DEVELOPMENT HOUSING POLICY	Housing development policy (HDP)	Economy dimension (Ec)	Social relationships (SR)	• Social conflict • Culture • Community relationship
	Environment policy (EnP)		Security and comfortable (SC)	• Status of house and land • Criminality • Fires
	Education policy (EdP)		Access to education (AE)	• Financial capability • Education facility
			Access to environment and health (AEH)	• Health facility • Disposal waste system • Drainage system
			Access to natural resources (ANR)	• Land • Water • Air
		Social dimension (Sc)	Employment (Em)	
			Technology (Tec)	
			Telecommunication (Tel)	
			Green space (GS)	
		Environment dimension (En)	Air quality (AQ)	
			Clean water (CW)	
			Wastewater (WW)	
			Solid waste (SW)	
			Environment conservation (EnC)	

This study used AHP model to determine the preferences of sustainable residential development. This model consists of four levels, including an objective level, the level of the criteria, sub-criteria and the level of alternative level. The goal is to determine the most appropriate decision on the development of sustainable housing. Multiple criteria of concern in the construction of sustainable housing, among others, the social dimension, the economic dimension and the environmental dimension. Each of these criteria has sub-criteria, such as social relationships, security and comfortable, access to education, access to environment and health, access to natural resources, employment, technology, telecommunication, green space, air quality, clean water, wastewater, solid waste, and environment conservation.

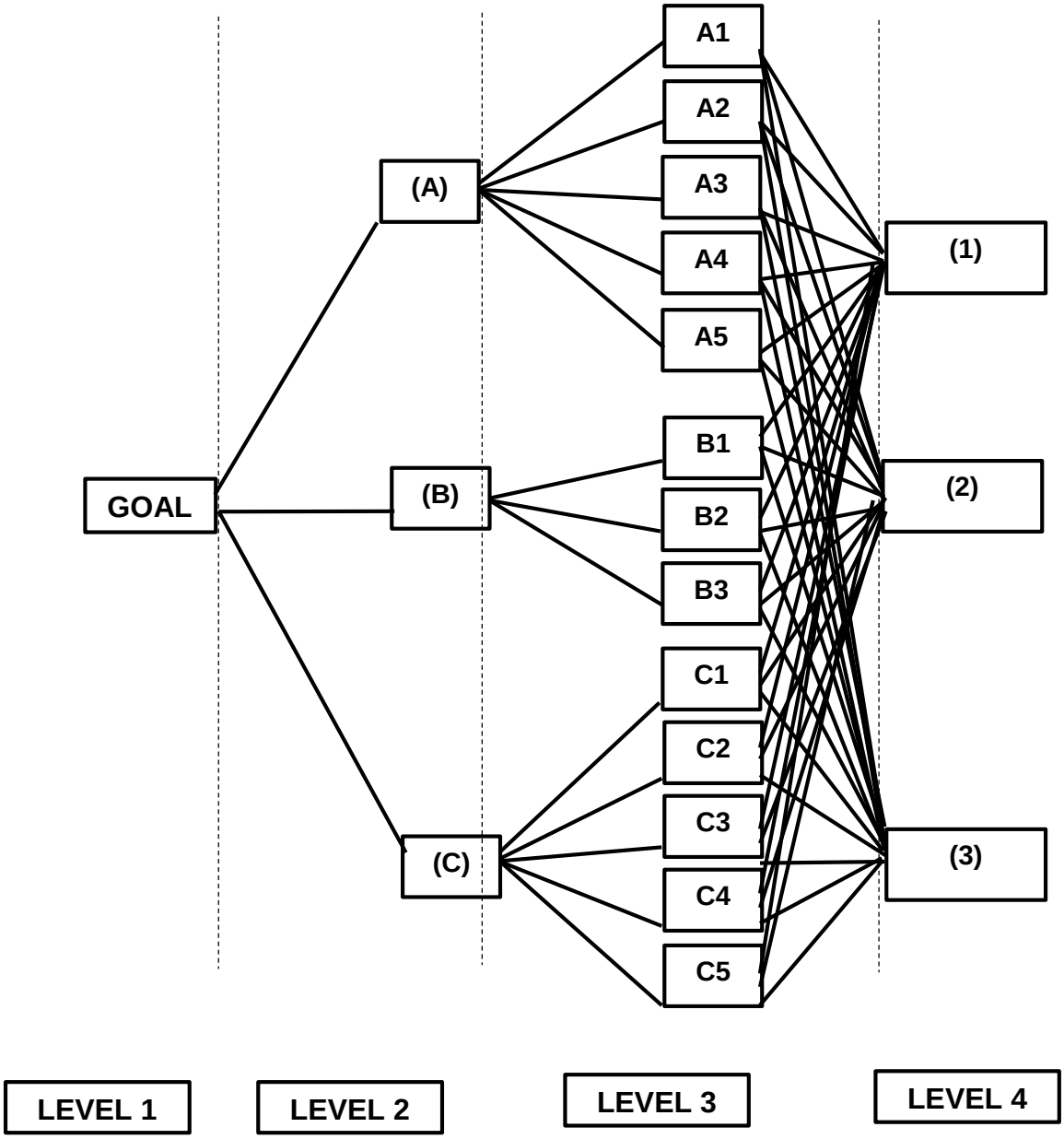

Figure 2. The hierarchy of decision making

In order to provide convenience on every level, then each factor criteria grouped into homogeneous groups (Saaty, 1980). Each factor in the criteria and sub-criteria have a significant association at every level and a higher level. In the hierarchical structure of the AHP, the highest level is a goal to be achieved in decision making. The second level is all factors that support decision making. While on the third level is a translation of the factors that exist on the second level. At the fourth level are alternatives that would be an option.

Table 4. Result of pair comparison in sub-criteria

Sub Criteria	Weight	**Social relationship**	**0.062**
Social conflict	0.135		
Culture	0.281		
Community relationship	0.584		
Status of house and land	0.651	Security and comfortable	0.103
Criminality	0.223		
Fires	0.127		
Financial capability	0.833	Access to education	0.160
Education facility	0.167		
Health facility	0.791	Access to environment and health	0.274
Disposal waste system	0.202		
Drainage system	0.097		
Land	0.584	Access to natural resources	0.401
Water	0.281		
Air	0.135		

Table 5. Result of pair comparison in sub-criteria

Criteria	Weight		
Social relationship	0.062	Social dimension (A)	0.105
Security and comfortable	0.103		
Access to education	0.160		
Access to environment and health	0.274		
Access to natural resources	0.401		
Employment	0.584	Economy dimension (B)	0.258
Technology	0.281		
Telecomunication	0.135		
Green space	0.117	Environment dimension (C)	0.637
Air quality	0.053		
Clean water	0.257		
Wastewater	0.078		
Solid waste	0.172		
Environment conservation	0.323		

Through the hierarchy, alternative selection criteria of each factor and sub-criteria in each stage to guide decision making. As explained earlier that the decision-making residential development of is composed of a variety of criteria, sub-criteria, and alternatives. Table 2 represents the identification of objectives to be achieved from several alternatives and criteria. Furthermore, the hierarchy of decision making will be shown in figure 2.

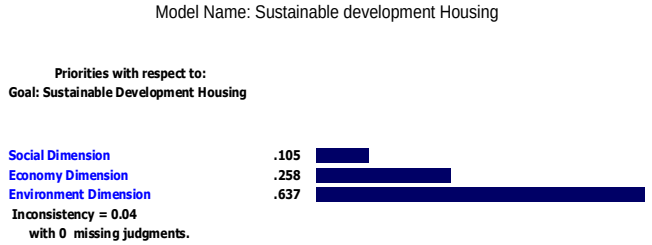

Figure 3. Priorities with respect to goal

According to on the data processing performed by assigning weights pairwise comparison of several of the goals desired criteria result as figure 3 above. Furthermore, the data processing is done using the Expert Choice software. As a result, the top priority in the decision is the environmental dimension (0.637), while the Social dimension is the lowest priority (0.105). In addition, the chart also provides information that the value of the inconsistency ratio of approximately 0.04. This is in accordance with the procedure of the AHP that the value of consistency must be <0.10. This means that the respondents remain consistent in providing answers to the selection on each criterion and sub-criteria.

Based on the calculation results are weighted pairwise comparisons on each criterion and sub-criteria, the results obtained, as Table 5.

Table 6. Significance of used alternative sustainable housing development policy

Alternatives Policy	Weight	Result
Housing development policy (HDP)	0.591	1
Environment policy (EnP)	0.278	2
Education policy (EdP)	0.131	3

From the table above it can be concluded that the policy of housing development of is a top priority that must be implemented (0.591), while the education policy is the lowest priority (0.113) in relation to decision-making, sustainable housing development policy.

The final step of the decision-making process is the implementation of sensitivity analysis. Stakeholders will be able to see the impact of changes in input data from each of the criteria. Results of graphics performance assumed strong sensitivity alternatives if the rating has not changed significantly. The picture 4 above is a view of the sensitivity performance of the alternative of choice in the selection decision making sustainable housing policy. Furthermore, the results of the calculations show that based on each criterion is chosen, then the alternative dimension of the environment is a top priority. The stakeholders may change the weighting of the criteria to obtain other alternative priorities by shifting the value of each criterion. However, in this study shows that there is no significant change to the existing alternatives from changes in the value criteria.

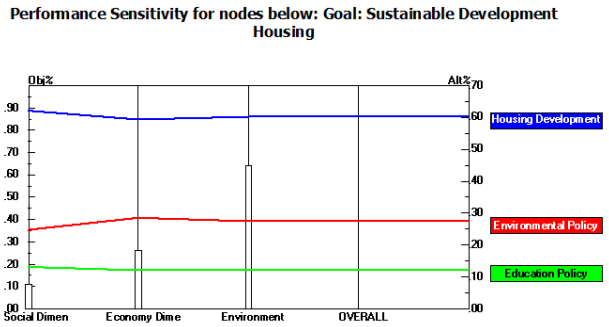

Figure 4. Performance Sensitivity for goal

CONCLUSION

Population growth in a world increasingly uncontrolled driving the need for housing is increasing. Residential development in some countries is always tailored to each country. This is because the housing development policies of each country have different criteria and alternatives in decision making. One factor determining the difficulty in making decisions is the factor criteria are very complex and complicated. AHP method can be one of the bridges to solve the problems of decision making that have a high complexity. This is indicated by the approach based on knowledge and experience of experts in determining the criteria and assessment of existing alternatives. The results showed AHP as the proper method for selecting the criteria and alternatives in policy decision making sustainable residential development in the village Ihamahu village at Maluku province, Indonesia. Thus, the results of this study can potentially be used for the implementation of a more comprehensive study of the factors that determines the preference of the decision making sustainable residential development in Indonesia.

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