Conference Paper

Adaptation of Rating System for Sustainable Housing and Settlements in Indonesia

Syarif Hidayatullah Santius

Research Institute for Housing and Human Settlements, Ministry of Public Works and Housing of The Republic of Indonesia, Panyaungan-Cileunyi Wetan, 40393 Kabupaten Bandung, Indonesia

Abstract

This paper describes the process of identification, weighting, and validation of assessment criteria for the sustainable housing and settlements rating system. The assessment criteria in this rating system divided into two categories, i.e., the environmental quality and load. The rating system criteria were selected using the Delphi Method, and their weight coefficients were obtained using Analytical Hierarchy Process (AHP). There are 37 criteria resulted from Delphi Consensus and grouped into the environmental quality and load category. The weight coefficients for three main criteria in the environmental quality category consist of (1) microclimate control and ecosystem conservation (0.439), (2) improvement of service function (0.384) and (3) improvement of citizen's welfare (0.177). The weight coefficients for three main criteria in the environmental load category consist of (1) reduction of the environmental load to other areas (0.432), (2) reduction of infrastructure load (0.381), and (3) environmental management (0.187). These criteria and their weight coefficients were then validated to obtain a correlation coefficient between rating values and citizen satisfaction. The validation result shows a positive and strong correlation. The rating system can be used by local governments to identify the sustainability level and to determine suitable development policies.

Keywords: sustainable, rating, housing, and settlements

Corresponding Author:
Syarif Hidayatullah Santius

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1. Introduction

The population of Indonesia in 2025 estimated will be 273 million. The proportion of the urban population in Indonesia continues to increase. According to Djaja [1], since 1970 the ratio of the urban population in Indonesia has increased from 17.4 percent to 22.3 percent (1980), 30.9 percent (1990), 43.99 percent (2002), 52.03 percent (2010) and in 2025 it is predicted to reach 67.5 percent. It implies that a large number of people will require a large number of resources.

The slum areas are one of the negative impacts of high population growth if not anticipated by the provision of adequate housing and infrastructure. High population growth also creates environmental problems; one of them is the increase of CO_2 emissions. Various studies conclude that housing and settlements provision has contributed significantly to CO_2 emissions which is one of the greenhouse gases (GHG) causes of global warming.

The United Nations Environment Program [2] states that successful cities should be able to balance social, economic, and environmental aspects. This balance is known as sustainable development. Sustainable development is a holistic system that integrates social, economic, and environmental aspects. This is by the outcome of city management as proposed by Kusbiantoro [3], namely livable city to work, to live, and to play, which is realized through sustainable economically, sustainable socially, sustainable culturally, and sustainable environmentally. The United Nations for the Commission on Sustainable Development (CSD) lists the institutional aspects as the fourth pillar. The institution is seen as a part that can facilitate programs and activities related to social, economic, and environmental issue [4].

In terms of institutional aspect, the most difficult challenge faced by urban managers in realizing sustainable cities is to draw up long-term projections of urban planning. Inappropriate policies can lead to severe consequences, increase public suffering, and can even become a catalyst for a crisis [4].

To solve this problem, one of the solutions can be adopted by developing an evaluation instrument or also called “rating system” to assess the condition of the city unit based on the achievement of the sustainable development values. One of the city units that has a vital role in influencing the sustainability of a city is the neighborhood.

There have been many rating systems developed such as Leadership in Energy and Environmental Design for Neighborhood Development (LEED-ND) used U.S, Canada and China, Earth Craft Communities (ECC) used in U.S, Comprehensive Assessment System for Building Environmental Efficiency for Urban Development (CASBEE-UD) used in Japan, Building Research Establishment Environmental Assessment Methods for Communities (BREEAM communities) used in U.K, and many others. However, most of these rating systems have not been easily adapted for other countries [5].

The difference in the benchmark in some rating systems will have implications for different ratings on the same neighborhood. The results of Sharifi’s [7] study indicate that there are significant differences in the ranking outcome in three regions using 3 rating system, as shown in Table 1.

Besides the differences in benchmarks that already mentioned, there are different criteria considered important for assessing sustainability in each rating system. On the other hand, not all criteria are suitable to be applied in different contexts. Sharifi [6]

Table 1: Rating results using three rating systems (Source: [6]).

Rating Kawasan	LEED-ND	BREEAM Communities	CASBEE-UD
Hoyt Yards (USA)	*Platinum (1)*	*Very good (3)*	*Very good (2)*
MediaCity (UK)	*Gold (2)*	*Excellent (2)*	*Very good(2)*
Koshigaya Lake Town (Jepang)	*Silver (3)*	*Good (4)*	*Excellent (1)*

exemplifies the existing earthquake safety criteria in CASBEE-UD will be incompatible if used in the context of the UK. The economic, cultural and social context of each country/region becomes vital in the development of a local rating system.

One of the findings proposed by Sharifi [6] is impossible to develop a global rating system. The emphasis on local aspects becomes very important in any rating system development. The development of the rating system is limited to the overall use of criteria or benchmark only. Meanwhile, the selection of criteria is left to the local planner or policy maker.

Based on that background, this research aimed to create the rating system for sustainable housing and settlements through the adoption of the other countries rating system and adapted to Indonesian characteristics.

2. Method

The data used in the process of selection and weighting of criteria are the data derived from questionnaires that have been filled by Delphi and AHP panelists. There are 11 panelists involved with various backgrounds such as academics and practitioners who have experience in sustainable development.

2.1. The selection and weighting of sustainability criteria

The sustainability criteria selected using the Delphi Method. In each round of the Delphi process, each panelist is asked to express their opinion on the importance of each criteria candidate based on the Likert Scale 1 to 5. Scale 1 means unimportant and 5 means very important. The consensus is expected to be achieved after several iterative processes. To measure the consensus, Landeta [7] used interquartile range (IQR) as shown in Equation (1).

$$IQR_i = Q_{3i} - Q_{1i} \tag{1}$$

with IQR_i = IQR criteria i, Q_{1i} = the first quartile of criteria i, Q_{3i}= third quartile of criteria i.

However, a consensus does not necessarily imply a high accuracy because consensus may occur in harmony and not in accuracy [8]. Nevertheless, some studies (e.g., Parenté et al. [9] & Riggs [10]) at least confirm group consensus in Delphi is relatively better in terms of accuracy than the average individual accuracy.

Because Delphi Method depends on panelist opinion, then panelist selection becomes one of the important stages in this research. To determine the panelists who are eligible to be a member of the panel, a brainstorming process conducted by compiling the names of academics and practitioners who are competent and have sufficient knowledge on the sustainable development. This selection is crucial to maintain the validity of the survey.

The weight coefficients for each criterion were obtained using Analytical Hierarchy Process (AHP) with the following stages:

1. Define the actual problem and determine the desired solution
2. Create a hierarchical structure
3. Create a pairwise matrix that describes the relative contribution of each element
4. Defines pairwise comparisons. According to Saaty [11], the results of the comparison of each component will be a number from 1 to 9 which shows the contrast of the importance of an element as shown in Table 2 below.
5. Calculate the eigenvalues and test their consistency using Equation (2).

$$A'w' = \lambda_{max}\hat{w}' \quad (2)$$

   With λ_max being the largest eigenvalue, **A** is the estimated reciprocal matrix, w' is the approximate weight, and ŵ' is the weight obtained. Consistency is calculated using a consistency ratio (CR) with the following Equation (3) and (4).

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (3)$$

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

   With RI value is a random consistency index with the reference value in Table 3. If RI value is inconsistent (indicated by CR> 10%), then data collection has to be repeated.

6. Repeat steps c, d, and e for the entire hierarchy level

7. Calculates the eigenvectors of each pairwise matrix
8. Check the consistency of the hierarchy. The consistency ratio is expected to be less than or equal to 10 percent.

Table 2: Scale of paired comparisons in AHP (Source: [11]).

Scale	Scale Definition	Description
1	*Equally Important*	Both criteria are equally important
3	*Moderately Important*	One criterion is quite important compared to one of the other.
5	*Strongly Important*	One criterion is more important than other criteria.
7	*Very Strongly Important*	One criterion is very more important than other criteria.
9	*Extremely Important*	One criterion is most important than one other criteria.
2, 4, 6, 8	*Intermediate Value)*	This value is used to describe the intermediate scale compromises described above.

Table 3: Value of random consistency index (RI) (Source: Saaty [11]).

N	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

2.2. Rating system validation

Before the rating system applied, validation needed to find out whether the rating system assessment result has represented the actual conditions. Validation is done through citizen's satisfaction survey in the village level (*kelurahan*) using a questionnaire. The survey locations covered 22 villages in seven cities in Indonesia. Village level was chosen for the reason of easiness in obtaining the data. Each village usually has population data, infrastructure, public facilities, and overall environmental conditions.

The rating value (R) for the villages calculated using Equation (5) [12]:

$$R = \frac{K}{B} = \frac{25\,(SK - 1)}{25\,(5 - SB)} \tag{5}$$

SK is the total score for quality aspect in the village area, while SB is the total score of the efforts to reduce environmental load. Rank and category of sustainable housing and settlements rating as shown in table 4 below.

The rating value of all villages is correlated with the level of citizen's satisfaction using Spearman Rank Correlation Analysis. Spearman rank correlation coefficient (ρ_s) is a number that describes the strength of correlation between two ordinal variables. This means that ρ_s is a measure of the degree of relationship between data that has

Table 4: Rank and category of sustainable housing and housing rating (Source: Pusperkim [13]).

Rank	Category	Rating (R)
A^+	Very Sustainable	R ≥ 3,0 and K ≥ 50
A	Sustainable	1,5 ≤ R < 3,0
B	Fairly sustainable	1,0 ≤ R < 1,5
C	Not sustainable	0,5 ≤ R < 1,0
D	Very not sustainable	< 0,5

been compiled by rank (ranked data). The correlation coefficient (ρ) is calculated using the actual values of X and Y, whereas Spearman's correlation coefficient (ρ_s) uses rank values for X and Y and is not an actual value (Supranto [14]). Spearman rank correlation coefficient (ρ_s) is calculated through the following Equation (6).

$$\rho_S = 1 - \left(\frac{6 \sum D^2}{n \left(n^2 - 1 \right)} \right) \quad (6)$$

The value of D is the deviation between the value of the variables X and Y, and n is the number of data (sample). The amount of ρs will be in the range of 0 to 1. The zero (0) value means there is no correlation between the variables X and Y, while the value of one (1) indicates there is a powerful correlation between variables X and Y. The following Table 5 is the classification of correlation coefficient values according to de Vaus [15].

Table 5: Classification of correlation coefficient values (Source: De Vaus [15]).

Coefficient	Meaning
0,00	No correlation
0,01 – 0,09	Correlation is less meaningful
0,10 – 0,29	Weak correlation
0,30 – 0, 49	Moderate correlation
0,50 – 0,69	Strong correlation
0,70 – 0,89	Very strong correlation
>0,90	The correlation is near perfect

3. Result and Discussion

3.1. The selected sustainable criteria

In the first stage of sustainable criteria selection using the Delphi Method, the selected criteria should get a score of four or more and selected by 70 percent or more panelists. In the first round, as many as 17 criteria (15.45 percent) must be eliminated and the remaining as many as 93 criteria (84.55 percent). In the second round, there are 49 additional criteria proposed by the panelists. The number of criteria in the second round that was eliminated as many as 40 criteria (25.16 percent) and the remaining as many as 119 criteria (74.84 percent).

Table 6 shows in the second round there was a consensus improvement although not as high as expected. The parameters used as an indicator of consensus improvement are: the average standard deviation value decreased by 0,05 from 0,79 to 0,74, the average IQR value decreased by 0,08 from 1,02 to 0,94, and the relative IQR value is decreased by 0,02%, from 0,25 to 0,23.

Table 6: Results of Delphi questionnaire analysis in round 1 and round 2 (Source: Pusperkim [13]).

Consensus Indicators	**Round 1**	**Round 2**
Score ≥4 and selected by ≥70% of respondents	Yes = 93 (84,55%) No = 17 (15,45%) Total = 110	Yes = 119 (74,84%) No = 40 (25,16%) Total = 159*)
Average Standard Deviation	0,79	0,74
Average *IQR* (*interquartile range*)	1,02	0,94
IQR (*interquartile range*)	≥2 = 12 <2 = 98 Total = 110	≥2 = 14 <2 = 145 Total = 159
Average Relative *IQR*	0,25	0,23

There are 119 selected criteria based on Delphi analysis in round 2 (Table 6). The following criteria selection process is the analysis of the readiness level for the application of sustainability criteria in the next five years. Similar to the previous stage, this selection was conducted through expert panelist opinion survey using a questionnaire. The selected criteria should get a minimum score of 3 (with 1 denoting “not ready” and 4 denoting “ready”) and chosen by 70 percent or more panelists. In this stage, there are 43 criteria that are considered ready to be applied in the next five years as seen in Table 7 below.

Table 7: Criteria that ready to be applied in the next five years (Source: [13]).

Criteria that Ready to be Applied (Score of 3 or more) and Selected By	**The Number of Criteria that Ready to be Applied in the Next 5 Years**	**The Number of Criteria that have not been Ready to be Applied in the next 5 years**
≥ 60 % panelists	64	55
≥ 70 % panelists	43	76
≥ 80 % panelists	16	103
≥ 90 % panelists	5	114
100% panelists	0	119

3.2. The weight coefficients

The number of selected criteria is 43. Based on the researcher team discussion, there are some criteria merged because they are considered to have similarities. The final selected sustainable criteria to be weighted as many as 37. The weighting method of the sustainable criteria process is conducted using AHP. The weight coefficients for all sustainable criteria as seen in Table 8 below.

Table 8: Sustainable criteria and weight coefficients (Source: [13]).

Environmental Quality in the Area				Weight
Improvement of citizen's welfare				**0.177**
K.1.1	Community empowerment			0.656
		1	Consideration of local conditions regarding area development	1.000
K.1.2	Local economic development			0.344
		1	Utilization of local resources (human resources. expertise. and raw materials) for the industrial sector	0.616
		2	Utilization of local food production	0.384
Improvement of service function				**0.384**
K.2.1	Drainage Infrastructure			0.232
		1	Provision of reliable drainage networks	1.000
K.2.2	Electricity networks infrastructure			0.244
		1	Provision of the reliable electricity network	1.000
K.2.3	Information and communication network infrastructure			0.099
		1	Provision of reliable information and communication networks infrastructure	1.000
K.2.4	Transportation facilities			0.175
		1	Provision of transit facilities	0.356
		2	Provision of reliable public transportation	0.644
K.2.5	Trade. education. and health facilities			0.200
		1	Providing sufficient trade. education. and health facilities	1.000
K.2.6	Institutional			0.051
		1	The existence of institutions that manage the infrastructure and facilities	1.000
Micro climate control and ecosystem conservation				**0.439**
K.3.1	Area design			0.301
		1	Provision of green open spaces	0.680
		2	Spatial and social integration design oriented	0.320
K.3.2	Land conservation			0.306
		1	Consideration of the land suitability in development	0.171
		2	Conservation of agricultural and productive land	0.370
		3	Consideration of soil contamination when developing area	0.148
		4	Revitalization of the negative valued land	0.099
		5	Maintaining the natural landscape character	0.211

Environmental Quality in the Area			Weight
K.3.3	Conservation of water resources and wetland		0.393
	1	Conservation of water bodies and wetlands	0.385
	2	Conservation of the natural water cycle through groundwater recharge	0.436
	3	Consideration of water quality	0.178
B	**Environment Load Reduction**		**Weight**
B.1	**Reduction of infrastructure load**		**0.381**
	B.1.1	Reduction of thermal impact on the other areas in the summer	1.000
		1 Utilization of permeable pavement	1.000
B.2	**Reduction of the environmental load to other areas**		**0.432**
	B.2.1	Water efficiency	0.187
		1 Utilization of rainwater	0.391
		2 Measurement of water usage volume	0.126
		3 The existence of policies related to saving water usage	0.271
		4 Campaign of water saving	0.212
	B.2.2	Rain water run off reduction	0.098
		1 Utilization of permeable material in pavement and drainage system	1.000
	B.2.3	Wastewater treatment	0.204
		1 Evaluation of the quality of water from the wastewater treatment plant	0.537
		2 Measurement of waste water production	0.177
		3 The existence of waste reduction socialization program	0.286
	B.2.4	Waste management	0.212
		1 Provision of adequate waste infrastructure	0.469
		2 The existence of waste management institution	0.341
		3 The existence of waste volume reduction campaign	0.190
	B.2.5	Energy efficiency	0.300
		1 Promoting of renewable energy utilization	0.181
		2 The existence of energy saving campaign	0.308
		3 Utilization of the energy saving infrastructure equipment	0.511
B.3	**Environmental management**		**0.187**
	B.3.1	Environmentally friendly construction management	1.000
		1 Utilization of reuse material in the construction	0.496
		2 Selection of material that hasn't a negative impact on health	0.504

3.3. Rating system validation

Figure 1 shows the rating values position for 22 villages. There are nine villages categorized as "not sustainable" (rank C) with a rating value range from 0.5 to 1.0. There are 11 villages classified as the "fairly sustainable" (rank B) with a rating value range from 1.0

to 1.5 and only two villages classified as ‘sustainable” (rank A) with a rating value range from 1.5 to 3.0.

Figure 1 also shows Tamansari Village in Bandung City has the lowest rating (0.51) and categorized as “not sustainable” (rank C). Belawan 1 Village in Medan City has the second lowest rating (0.54) and classified as “not sustainable” category (rank C). Tambelan Sampit Village in Pontianak City has the third lowest rating (0.57) and also classified as “not sustainable” (rank C).

The highest rating value obtained by Sekeloa Village in Bandung City with the rating value 1.61 and categorized as “sustainable” category (rank A). Terban Village in Yogyakarta City has the second highest rating (1.57) and also classified as a “sustainable” type (rank A).

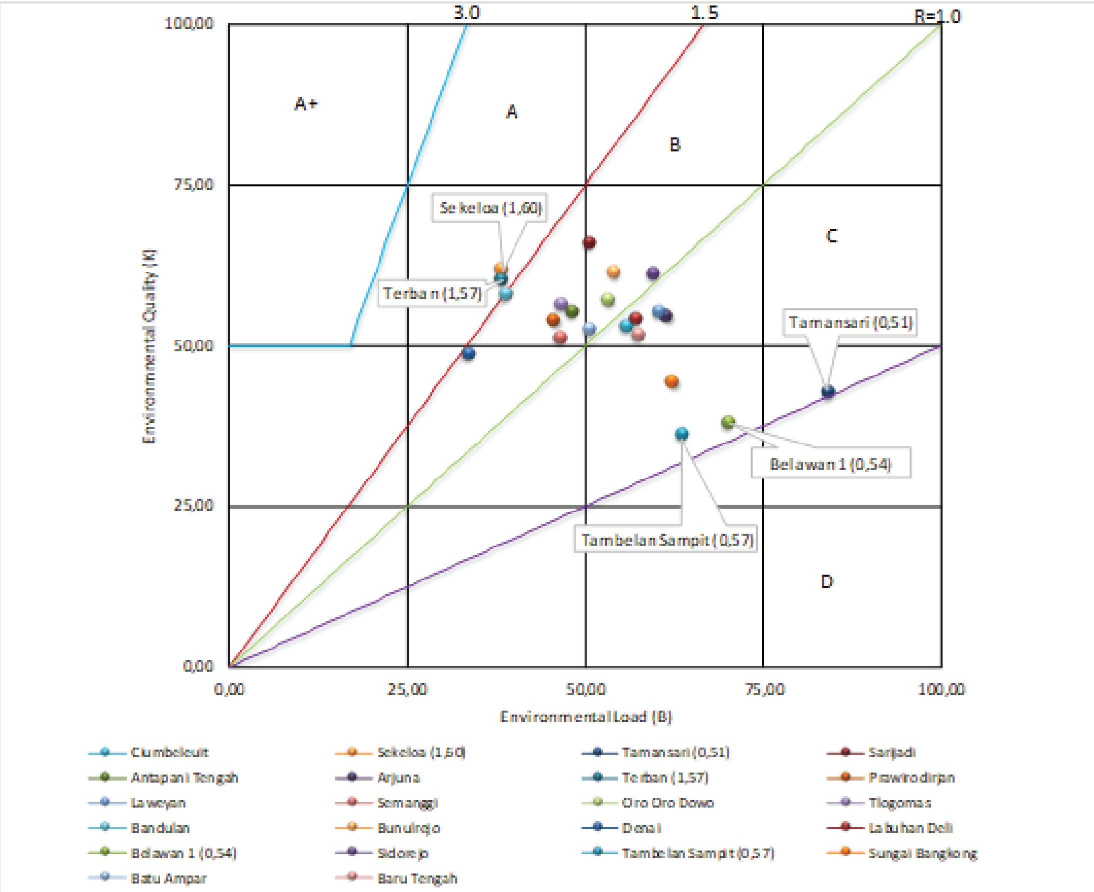

Figure 1: Rating of 22 villages in seven cities (Source: Pusperkim [13]).

The objective of rating system validation is to find out how accurate the rating value represents the actual conditions within the assessed area. The exact conditions are known through a direct survey to the citizen within the assessed areas (villages) using a questionnaire. The level of citizen’s satisfaction measured using a scale of 1 to 5 with 1 meaning very dissatisfied and 5 meaning very satisfied. The questions in the questionnaire were derived from the criteria used in the rating system.

The correlation between rating value and the citizen's satisfaction is calculated for all villages. There are 13 parameters used in calculating the correlation coefficient as shown in table 9 below.

Table 9: Parameters used in calculating correlation coefficient (Source: [13]).

No	Parameters
1	Drainage infrastructure
2	Electricity
3	Information and communication network
4	Transit facility
5	Public transportation
6	Trading facility
7	Education facility
8	Health facility
9	Institution performance
10	Open green space
11	Wastewater treatment facility
12	Waste infrastructure
13	Water conservation

The correlation (ρ_s), significance value (Sig), and determination coefficient (R^2) for the linear regression equation between rating value and the citizen's satisfaction in 22 villages can be seen in Figure 2 below. The correlation will be positive or negative. A positive relationship means if rating value is high, then citizen's satisfaction is also high, vice versa.

Based on Figure 2, there is a positive correlation between rating value and citizen's satisfaction. Positive correlation value can be seen from the coefficient of *an* in the equation y = *a*x + *b* is positive. The correlation is also strong, as can be seen, the correlation coefficient (ρ_s) is 0,605 and statistically significant (sig<0.05).

4. Conclusion

Based on the correlation results from 22 villages, there is a positive and strong correlation between the rating values with the citizen's satisfaction. Therefore, it can be concluded that the rating results are sufficient to represent the real condition of citizen's satisfaction and can be used to assess the sustainability of the housing and settlements in Indonesia.

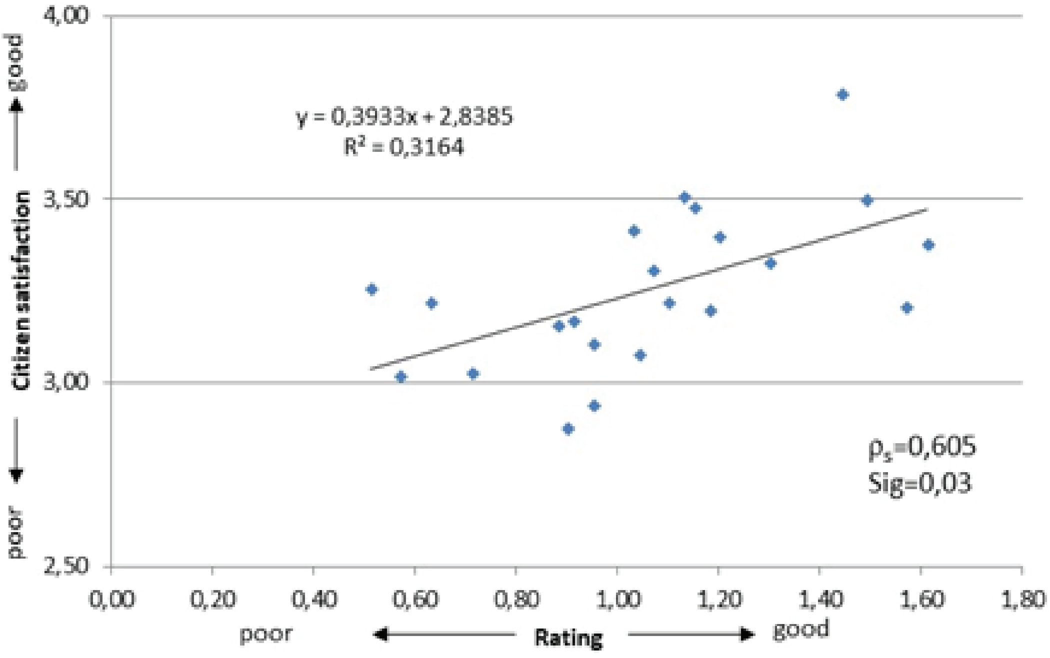

Figure 2: Correlation between rating value and citizen's satisfaction in 22 villages (Source: Pusperkim [13]).

The limitation of this research is the small number of panelists involved. For further research, there should be more panelists involved in various disciplines and professional backgrounds related to sustainable development.

Finally, the results of this study can be used by any stakeholders, especially the local governments to identify the sustainability level on their region and at the same time to make the right policies in every development program.

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