Probability Model for Designing Environment Condition

Iswar Lubis¹, Mahyuddin K M Nasution²*
¹Pengembangan Wilayah, Universitas Sumatera Utara, Padang Bulan USU Medan 20155, Indonesia.
²Information Technology, Fasilkom-TI, Universitas Sumatera Utara, Padang Bulan USU Medan 20155, Indonesia.

*Email: mahyuddin@usu.ac.id

Abstract. Transport equipment has the potential to contribute to environmental pollution. The pollution impact on the welfare of the environment. Thus, the potential of the environment needs to be raised to block the pollution. A design based on probability models of the determining factors in the environment should be a concern. This paper aims to reveal the scenarios as the beginning to express the clues, and based on surveys have been had the ability to choose a design.

1. Introduction
A fun environment is a major part of welfare, whereby residence be dominant basis for generating the travel that caused transportation [1]. One of the reasons why the environment is not pleasant is presence of noise [2]. Noise caused by means of transportation. The noise can be mitigated by involving factors anticipation, and the factors need management to conform to social [3]. Therefore, a probability model is proposed by developing the data collection of factors as data engineering for designing environment condition. A lot of researchers have developed technology to reduce noise, but little study on the management of environmental conditions involve related factors based on probability theory.

This paper aims to address a model for dealing with the data collection to managing the environment conditions. Therefore, after introduction section we introduce some concepts for motivating this research, mainly to review some of researches, and then propose an approach based on scenario. After that, some results discussed by comparing the results.

2. Basic Concept and Motivation
Noise is defined as pollution of voice due to the influx of unwanted noise into an environment that causes environmental degradation, resulting in certain activities such as schools, housing and hospitals [4]. The noise happens to be very disturbing ongoing activities on the environment, even if noise that occurs accepted by humans at a certain time with a certain level will endanger human health itself [5]. Therefore, some areas such as housing allotment endeavoured by imposing noise threshold corresponding to the quality standard that is free from noise pollution. For example, The Decision Minister of Environment No. KEP-48/MENLH/11/1996 on Standards of Noise Level.

Enforcement of a rule is one of attempts that is based on legislation to reduce the noise level to suit the needs of the environment. Another effort is to involve factors is available in the neighborhood itself [6]. Factors that come from the environment is the work and materials. It also related to the budget as external factor. Material factors among them are the fence, the trees, the grass, study room, bedroom, distance, soundproof, wall, window, etc. While work factors like installation, enhancement,
rehabilitation, increase, improve, etc. However, how far all these factors favored by social members need to summarize well.

Probability theory has proven itself useful in the study of noise by transportation [7], but the model is to predict flow roads. Other model, but does not involve probability, is used to determine equivalence of annoyance [8]. Research on transportation generally does not rely to cope with noise or relating to environment, but is related to technology and technical transport [9, 10, 11].

3. Proposed Approach

In general, in any event there is a series of interrelated activities [12]. These activities become the factors of success of the event. The success of an event depends on the opportunities and expectations (also called probability) [13]. To determine the probability model among the factors we construct several scenarios as events, i.e:

1. Environmental conditions are offered on scenario-1 (S1) is a reduction in noise levels by 5 dB(A) through improved quality of fence at an additional cost of Rp. 40,000 per month.
2. The scenario-2 (S2) offered an environment where the noise level that exists today remains reduced by 5 dB(A) as well as scenario-1, but it done through efforts to improve the garden at an additional cost of Rp. 50,000 per month.
3. Scenario-3 (S3) offers an environment with reduced noise level of 10 dB(A) through improving the quality of the wall/window by turn to the type of soundproof or another with an additional fee or Rp. 50,000 per month.
4. In scenario-4 (S4), environmental conditions offered experiencing a reduction in noise levels of 10 dB(A) as well as scenario-3, but in the reduction scenario conducted through the rehabilitation of study room / work room with an additional fee of Rp. 25,000 per month.
5. Reduction of the noise level of 20 dB(A) through the rehabilitation of the breakroom/bedroom with an additional fee of Rp. 25,000 per month as offered in scenario-5 (S5).
6. In the scenario-6 (S6), the conditions offered are the reduction of noise by 10 dB(A) through improved quality garden and fence once with an additional fee of Rp. 75,000 per month.
7. An additional fee Rp. 75,000 per month on the reduction of the noise level of 15 dB(A) through improving the quality of fence and wall/window are done at once (Scenario-7 (S7)).
8. In scenario-8 (S8) made bids reduction of the noise level of 15 dB(A) through the rehabilitation of the fence and the study room / work room as well as an additional cost of Rp. 50,000 per month.
9. Scenario-9 (S9), which offered a condition of reduction of the noise level of 25 dB(A) through improving the quality of the fence and breakroom/bedroom with an additional fee of Rp. 50,000 per month.
10. In the scenario-10 (S10), offered environmental conditions is a reduction in the noise level of 15 dB(A) as a result of the efforts made by improving the quality of the garden and the wall/window at once with the amount of additional cost Rp. 75,000 per month.
11. Environmental conditions are offered on scenario-11 (S11), namely the reduction of the noise level of 15 dB(A) through quality improvement and rehabilitation of the garden and the study room / work room as well at an additional cost of Rp. 60,000 per month.
12. Scenario-12 (S12) offer an environment where there are reduction in the noise level of 15 dB(A) through the quality improvement and rehabilitation of garden and breakroom/bedroom with an additional fee of Rp. 60,000 per month.
13. The last scenario (S13) offered is a reduction in the noise level of 25 dB(A) through improved quality fence, garden and wall/window at once, where the reduction is greatest reduction of scenarios offered at an additional cost of Rp. 75,000 per month.
Of the 13 scenarios we have factors such as Table 1 and Table 2.

**Table 1. Variables about noise reduction and additional cost**

| Id | Noise reduction (dB(A)) | Scenario | Id | Additional Cost (Rp) | Scenario |
|----|-------------------------|----------|----|----------------------|----------|
| N1 | 5                      | 1, 2     | C1 | 25,000               | S4, S5   |
| N2 | 10                     | 3, 4, 6, 10 | C2 | 40,000               | S1       |
| N3 | 15                     | 7, 8, 11, 12 | C3 | 50,000               | S2, S3, S8, S9, S11, S12 |
| N4 | 20                     | 5        | C4 | 60,000               | S11, S12 |
| N5 | 25                     | 9, 13    | C5 | 75,000               | S6, S7, S10, S13 |

**Table 2. Variables about works and material**

| Id | Works and Materials | Scenario |
|----|---------------------|----------|
| F1 | Improve quality of fence | S1, S6, S7, S9, S13 |
| F2 | Improve quality of garden | S2, S6, S10, S11, S12, S13 |
| F3 | Improve quality of wall/window | S3, S7, S10, S13 |
| F4 | Improve quality of breakroom / bedroom | S9, S12 |
| F5 | Improve quality of study room / work room | S11 |
| F6 | Rehabilitation of study room / work room | S4, S8, S11 |
| F7 | Rehabilitation of breakroom / bedroom | S5, S12 |
| F8 | Rehabilitation of fence | S8 |
| F9 | Rehabilitation of garden | S11, S12 |

To build probability model required initial value. Each factor has a probability $p$ (factor) in $[0, 1]$. For example, probability of noise reduction for 5dB(A) based on Table 1 is $2/13$ or $p(N_1) = 0.15$, probability of additional cost for Rp. 75,000 based on Table 1 is $4/13$ or $p(C_5) = 0.31$, while probability of improve quality of garden in Table 2 is $6/13$ or $p(F_2) = 0.46$.

**Table 3. Probability of Out/In for network in Fig. 1.**

| Scenario | Out | In | Out | In | Out | In |
|----------|-----|----|-----|----|-----|----|
| 1        | 1/3 | 2/3 | 2/4 | 2/4 | 2/4 | 1/4 |
| 2        | 1/3 | 2/3 | 2/4 | 2/4 | 2/4 | 1/4 |
| 6        | 1/3 | 1/3 | 2/4 | 2/4 | 2/4 | 2/4 |
| 6        | 1/3 | 1/3 | 2/4 | 2/4 | 2/4 | 2/4 |

**Fig. 1. Network of factors for scenario 1, 2, and 6**

Suppose taken scenario-1, scenario-2 and scenario-6, we have a network such as Fig. 1, and Table 3. Based on multiplication probability we have probability $p$ (scenario-1) = $p$ (scenario-2) = 0.0069, while $p$ (scenario-6) = 0.0139. Therefore, probability model of a network based on scenario is

$$p(\text{scenario}) = \Pi_{\text{out/in}} p(out/in)$$

where row is number of row in the table of out/in. However, the initial value of each scenario is based on answers to the questionnaire by the stated preference methods [14].
4. Results and Discussion

To obtain responses to scenarios conducted a survey of the area. In general respondents on each bid is quite varied. The response options that have been declared in the survey are: (1) definitely disagree, (2) tend to disagree, (3) undecided, (4) tend to agree, or (5) would agree. By involving 38 respondents we obtained responses such as Table 1. Therefore, scenario sure approved has the probability: \( p_{(scenario-5)} = \frac{32}{38} \), \( p_{(scenario-4)} = \frac{29}{38} \), \( p_{(scenario-13)} = \frac{28}{38} \), etc.; scenario tend to agree has the probability: \( p_{(scenario-3)} = \frac{30}{38} \), \( p_{(scenario-8)} = \frac{29}{38} \), \( p_{(scenario-12)} = \frac{28}{38} \), etc.; while scenario was ignored has the probability: \( p_{(scenario-10)} = \frac{28}{38} \), \( p_{(scenario-9)} = \frac{24}{38} \), etc.; and then scenario definitely disagree has probability: \( p_{(scenario-1)} = \frac{27}{38} \), \( p_{(scenario-6)} = \frac{29}{38} \), \( p_{(scenario-7)} = \frac{28}{38} \), etc.

| Scenario | Response |
|----------|----------|
| S1 | 1 | 30 | 2 | 3 | 2 |
| S2 | 27 | 4 | 2 | 2 | 4 |
| S3 | 2 | 2 | 24 | 6 | 3 |
| S4 | 1 | 1 | 3 | 4 | 29 |
| S5 | 1 | 1 | 3 | 1 | 32 |
| S6 | 4 | 29 | 2 | 2 | 1 |
| S7 | 3 | 1 | 4 | 4 | 26 |
| S8 | 2 | 3 | 2 | 30 | 1 |
| S9 | 3 | 1 | 4 | 4 | 26 |
| S10 | 0 | 3 | 28 | 5 | 2 |
| S11 | 1 | 2 | 1 | 30 | 3 |
| S12 | 1 | 4 | 1 | 29 | 3 |
| S13 | 0 | 3 | 2 | 5 | 28 |

Table 1. Recapitulation of respondents to the scenario offered.

Suppose the scenario is taken in accordance with the highest ranking is based on the option (5), acquired three top scenarios with the series of probability as follows:

1. S5: \( \frac{1}{3}(1/3)(1/5)(1/5)(1/5)(2/5) \)
2. S4: \( \frac{1}{3}(1/3)(1/5)(1/5)(1/5)(2/5) \)
3. S13: \( \frac{1}{3}(1/3)(3/5)(1/5)(1/5)(3/5) \), etc.

Based on Eq. (1) and network of factors in S5, S4 and S13, we have \( p(S5) = p(S4) < p(S13) \). Furthermore, suppose 4 top scenarios based on the option (5), their probabilities as follows:

1. S5: \( \frac{1}{4}(1/4)(1/7)(1/7)(1/6)(2/6) \)
2. S4: \( \frac{1}{4}(1/4)(1/7)(1/7)(1/6)(2/6) \)
3. S13: \( \frac{1}{4}(1/4)(3/7)(1/7)(1/6)(4/6), \frac{1}{4}(1/4)(3/7)(2/7)(1/6)(4/6), \frac{1}{4}(1/4)(3/7)(1/7)(1/6)(4/6) \)
4. S7: \( \frac{1}{4}(1/4)(2/7)(2/7)(1/6)(4/6), \frac{1}{4}(1/4)(2/7)(1/7)(1/6)(4/6) \)

So the choice remains in the scenario-13 whereby F1 = “Improve quality of fence”, F2 = “Improve quality of garden”, and F3 = “Improve quality of wall/window” be the activities of social members.

Then, on development and maintenance fences: The results of the survey showed that of the 38 residents of the housing is used as respondents there were as many as 16 respondents were fully aware that the construction of the fence they have done is one of the efforts to block the entry of sound (noise) into the house and from a number of the average respondent to respond that of a number of costs that they incur in the form of development on average Rp. 1.48 million per year; in garden maintenance: The
efforts that have been made in form of a garden maintenance, survey results indicate that there are 28 respondents gave answers that have been doing the maintenance of the garden with an average of Rp. 85,000 per month; while for wall/window: Stated preference survey results showed that there were 11 respondents who had made a change/replacement or enhancement of the wall/window with an average cost of Rp. 557,000 per year.

The probability model based on generation of initial value and rank based on the probability of the option provide a selection condition for designing an environment that block the noise.

5. Conclusion
To develop probability model for the object of study can be done by building scenarios. Scenario used to weave related factors, as well as guidance for designing the environmental conditions. So the probability to ensure a successful design. The future work is to develop the probability network for preventing and considering the noise.

References

[1] O M Rouhani, R R Geddes, H O Gao, and G Bel 2016 Social welfare analysis of investment public-private partnership approaches for transportation projects Transportation Research Part A: Policy and Practice 88.
[2] M Foraster, I C Eze, D Vienneau, M Brink, C Cajochen, S Caviezel, H Heritier, E Schaffner, C Schindler, M Wanner, J-M Wunderli, M Roosli, and N Probst-Hensch 2016 Long-term transportation noise annoyance is associated with subsequent lower levels of physical activity Environment International 91.
[3] R Year, J Castro, and L Martinez 2016 A fuzzy model for managing natural noise in recommender system Applied Soft Computing 40.
[4] L Brocolini, E Parizet, and P. Chevret 2016 Effect of masking noise on cognitive performance and annoyance in open plan offices Applied Acoustics 114.
[5] Z Li, Z Song, T Wang, Y Zheng, and X Ning 2016 Health impacts of construction noise on workers: A quantitative assessment model based on exposure measurement Journal of Cleaner Production 135.
[6] T Wilkening 2016 Information and the persistence of private-order contract enforcement institutions: An experimental analysis European Economic Review 89.
[7] F Li, S S Liao, and M Cai 2016 A new probability statistical model for traffic noise prediction on free flow roads and control flow roads Transportation Research Part D: Transport and Environment 49.
[8] L-A Gille, C Marquis-Favre, and J. Morel 2016 Testing of the European Union exposure-response relationships and annoyance equivalents model for annoyance due to transportation noises: The need of revised exposure-response relationships and annoyance equivalents model Environment International 94.
[9] F Asgari, A Sultan, H Xiong, V Gauthier, and M A El-Yacoubi 2016 CT-Mapper: Mapping sparse multimodal cellular trajectories using a multilayer transportation network Computer Communications 95.
[10] H R Eftekhar and M Ghatee 2016 An inference engine for smartphone to pre-process data and detect stationary and transportation modes Transportation Research Part C: Emerging Technology 69.
[11] D Teodorovic and M Janic 2017 Chapter 11 – Transportation, environment, and society Transportation Engineering.
[12] M K M Nasution, and S A M Noah 2011 Extraction of academic social network from online database, Proceeding of 2011 International Conference on Semantic Technology and Information Retrieval (STAIRS’11), 64-69, IEEE, Putrajaya, Malaysia (2011).
[13] R A Halim, J H Kwakkel, and L A Tavasszy 2016 A scenario discovery study of the impact of uncertainties in the global container transport system on European ports Future 81.
[14] E P Kroes and R J Sheldon 1998 Stated preference methods *Hague Consulting Group, The Hague, Netherlands.*