The Benefit of Infrastructure Development: An Analysis

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Abstract. In analyzing the benefits of infrastructure development, several rules of economics and feasibility studies for infrastructure development are used, namely aspects of benefits, effectiveness and efficiency. These rules are applied to the results of the benefits data when infrastructure development is carried out in the first year and the results of the benefits data are processed using mamdani fuzzy logic reasoning which consists of 2 inference processes. In processing fuzzy input data produces output from the inference process which is then classified in 5 feasibility conditions, namely, low, normal, high, very high and not feasible which is used as a support facility in making infrastructure development decisions.

1. Introduction
The increasing rapidly development of the era triggered the government's performance in terms of equitable development in each region in Indonesia. Infrastructure development in each region is one of the government's efforts to improve the welfare of the Indonesian people [1]. So that to see an infrastructure development in an area that is really beneficial to improve the welfare of the people around, it is necessary to design a computer application that can analyze the benefits of infrastructure development that has been implemented in area that is in accordance with government objectives and shows a percentage value that represents the level of prosperity of the local people after infrastructure development was carried out.

This system is an analysis of the benefits of infrastructure development based on fuzzy logic that shows the level of feasibility of infrastructure development in an area, so that it is expected to facilitate officers working to evaluate infrastructure development in an area in determining which areas can be used as development priorities and which areas need to be evaluated re-building the project. Thus, the initial goal of the government to improve people's welfare and equitable development through infrastructure development in the regions can be achieved.

The purpose of this research is to design an analysis of the benefits of infrastructure development based on fuzzy logic in an area that can analyze the increase in the level of people's welfare in an area after infrastructure development is carried out.

To avoid extensive discussion, the author will limit the discussion of this Final Project with riset Analysis of people's prosperity in terms of economics and infrastructure development feasibility studies. Rules are determined based on the experience of the PNPM PISEW economic expert team in
analyzing the benefits of infrastructure development. Analyzing the prosperity of the people only in Sitinjo sub-district, Dairi Regency, where infrastructure development has been carried out by PNPM PISEW. Analysis of the system model mamdani method fuzzy inference system

2. Methodology
2.1 System Application Thinking Framework
The first step is to develop the benefits of infrastructure development variables according to figure 1, where the benefit variable consists of 3 aspects, namely aspects of efficiency, aspects of effectiveness and aspects of benefits. These three aspects are measured from the following parameters, namely: the benefits of rolling out funds, saving benefits, benefits of increasing production, BC Ratio, increasing access to economic business productivity, facilitating social relations of citizens, increasing accessibility of the poor and opening isolation among citizens. The following is a system application framework. The benefits of developing fuzzy logic base on infrastructure development.

![Diagram](image)

**Figure 1.** Framework system thinking.

For sensitivity analysis calculations to see how many percent increase and decrease the factors that cause changes in the benefits of infrastructure development in each aspect, namely from proper, normal or improper so that it needs to be re-evaluated against the process of infrastructure development. Figure 1 is the framework of the application system that will be built.
2.2 Flowchart Research
Flowchart is a scheme that describes the sequence of activities from beginning to end. Flowcharts are used to describe a program algorithm in an easier and simpler way. The process that occurs in this system can be described in the flowchart as shown in figure 2 below:

![Flowchart](image)

**Figure 2.** Flowchart of the FIS problem solving process using Mamdani Method.

Based on the figure 2 can be explained that the data training is the first data must be there and stored in the computer. Then the training data must first be normalized using the formula contained in equation (1). The normalized data will then be processed using backpropagation algorithm parameter using the bipolar sigmoid activation function. The next stage of the network will train the data training based on the parameters that have been determined. After all the steps are done, it will get the best testing results that will be used to predict.

2.3 Determine fuzzy sets and inputs
Based on figure 1 can be determined there are 10 fuzzy variables that can be model are namely:

i. BC Ratio (BcR) consists of 4 fuzzy sets, namely: low, normal, high and very high.
ii. Increasing access to economic productivity (Pr) consists of 6 fuzzy sets, namely: very low, low, normal, very normal, high and very high.
iii. Facilitating citizens' social relations (SR) consists of 3 fuzzy sets, namely: Low, Medium and High.
iv. Increasing community accessibility (Acc) consists of 6 fuzzy sets, namely: very low, low, normal, very normal, high and very high.
v. Opening isolation between citizens (Is); consists of 3 fuzzy sets, namely: low, medium and high.
vi. Effectiveness aspects (Ef) consist of 4 fuzzy sets, namely: very low, low, normal and high.

vii. The saving benefit (Sa) consists of 4 fuzzy sets, namely: low, normal, high and very high.

viii. The benefits of increasing income (Inc) consist of 4 fuzzy sets, namely: low, normal, high and very high.

ix. The benefits of rolling out funds (Fu) consist of 4 fuzzy sets, namely: low, normal, high and very high.

x. Benefits (B) aspects consist of 4 fuzzy sets, namely: low, normal, high and very high.

2.4 Membership function

Facilitating citizens' social relations (Sr) is shown in figure 3 below.

Membership function:

\[
\mu_{HUS} \text{ Low }[h] = \begin{cases} 
1; & h \leq 30 \\
\frac{(50-h)}{20}; & 30 \leq h \leq 50 \\
0; & h \geq 50
\end{cases} 
\]  \hspace{1cm} (1)

\[
\mu_{HUS} \text{ Normal }[h] = \begin{cases} 
0; & h \leq 40 \text{ or } h \geq 60 \\
\frac{(h-40)}{10}; & 40 \leq h \leq 50 \\
\frac{(60-h)}{10}; & 50 \leq h \leq 60
\end{cases} 
\]  \hspace{1cm} (2)

\[
\mu_{HUS} \text{ High }[h] = \begin{cases} 
0; & h \leq 50 \\
\frac{(h-50)}{30}; & 50 \leq h \leq 80 \\
1; & h \geq 80
\end{cases} 
\]  \hspace{1cm} (3)

Figure 3. Fuzzy set of levels of citizens Social Relations (Sr).

3. Results And Discussion

3.1 Display of effectiveness aspect input

The following is a membership function of the productivity aspect of the productivity variable input which consists of 5 conditions, namely low, medium, very medium, ordinary, very ordinary and high according to formula (1), (2) dan (3).
Next is the display of the aspects of effectiveness of the input variables of social relations where this input has the appearance of a membership function consisting of 3 conditions namely low, medium and high. Figure 4 shows a display of the effectiveness aspects of the input accessibility variable of the community where this input has the appearance of a membership function consisting of 6 conditions namely low, medium, very medium, ordinary, very ordinary and high. The following is a display of the accessibility input membership function.

Figure 5 shows a display of the effectiveness aspects of the community isolation input variable where this input has the appearance of a membership function consisting of 3 conditions, namely low, medium and high following is a display of the community isolation input membership function. It can be seen in the image display that the low and high conditions use the tramp curve type while the conditions using the trim curve type (triangle), the parameter values. These can be seen in Figure.
Figure 6 is a display of the effectiveness aspects of the community isolation input variable where this input has the appearance of a membership function consisting of 3 conditions, namely low, medium and high according to equations 3.20, 3.21 and 3.22. The following is a display of the community isolation input membership function. It can be seen in the image display that the low and high conditions use the trapezoid curve type while the conditions using the trim curve type (triangle), the parameter values shown are adjusted to equations 3.20, 3.21 and 3.22. These can be seen in Figure 7.

**Figure 6** Display accessibility membership functions.

**Figure 7.** Display of isolation membership functions.
3.2. Display of Benefit Inference Results

After all membership functions of each input are filled. Then the rule button contains a rule that is used for the benefit aspects in accordance with the rule in figure 8.

Then the view rules button will display the results of the centroid benefit analysis as seen in figure 7. Similarly, the results of the analysis of effectiveness in the display of results can also be changed in the input values so as to produce a variable output value. To change the input value can be done by changing the value in the text input in the lower left panel or it can also be done by sliding the red line on each input curve to the left or right. The shape of the blue curve is the output curve and the output value on this aspect of benefit, which is what appears in the description of benefits, while the yellow curve is the input curves whose values can be changed so as to produce varying output values.

![Figure 8. Display of functionality function.](image)

In Figure 8, the input value can be changed in the input text on the lower left, by changing the input values, we can obtain a varied output value. Furthermore, the changes made in the input column can be seen the results in the testing table 1 Every changing made to the input value will result in a significant change in the output, then the output is then classified into 5 conditions of the feasibility analysis system of benefits.

3.3 Testing

From the tests performed, where the user enters fuzzy input as follows:

- BC Ratio = 2.8
- Productivity access = 53
- Social Citizens = 49
- Community Accessibility = 61.4
- Inter-citizenship isolation = 41.2
- Savings = 2.47
- Income Increase = 1.9
- Revolving of Funds = 3.22

Fuzzy input will go through the inference process 1, then the inference 2 process in the form of classification of feasibility in this case consists of 5, namely feasible, very feasible, normal, very
normal and not feasible. Following are the details of the process. For the calculation of inference 1 aspect of effectiveness begins with the calculation of the implications of the implications.

### 3.4 Application function implications

Based on the rules in figure 8, the rules of the predicate α-pred can be determined as following:

#### Inference 1 effectiveness

- Pers 3.5; Pers 3.10; Pers 3.10; Pers 3.18:
  
  \[ R_1 = \alpha\text{-pred} = \min (\mu_{\text{AkP Normal}}, \text{HuS Low1}, \text{AkM Low2}, \text{IsW normal3}) \]
  
  \[ = \min (0,0,0,0) \]
  
  \[ = 0 \]

- Pers 3.6; Pers 3.11; Pers 3.14; Pers 3.19:
  
  \[ R_2 = \alpha\text{-pred} = \min (\mu_{\text{AkP very normal}}, \text{HuS normal1}, \text{AkM very normal2}, \text{IsW normal3}) \]
  
  \[ = \min (0,0,0,0) \]
  
  \[ = 0 \]

- Pers 3.7; Pers 3.12; Pers 3.15; Pers 3.20:
  
  \[ R_3 = \alpha\text{-pred} = \min (\mu_{\text{AkP normal}}, \text{HuS high1}, \text{AkM normal2}, \text{IsW high3}) \]
  
  \[ = \min (0,0.67,0.8,0.33) \]
  
  \[ = 0.33 \]

- Pers 3.8; Pers 3.12; Pers 3.16; Pers 3.20:
  
  \[ R_4 = \alpha\text{-pred} = \min (\mu_{\text{AkP very normal}}, \text{HuS normal1}, \text{AkM very normal2}, \text{IsW normal3}) \]
  
  \[ = \min (0.8,0.67,0,0.33) \]
  
  \[ = 0.33 \]

- Pers 3.9; Pers 3.10; Pers 3.17; Pers 3.18:
  
  \[ R_5 = \alpha\text{-pred} = \min (\mu_{\text{AkP low}}, \text{HuS low1}, \text{AkM low2}, \text{IsW normal3}) \]
  
  \[ = \min (0,0,0,0) \]

#### 3.5 Rule composition

Inference 1 effectiveness from the rules of the existing predicate, the fuzzy boundary region is generated as follows:

\[
(e_1 - 65)/20 = 0.33 \\
e_1 = 71.67 \\
(85 - e)/20 = 0.33 \\
e_2 = 78.33
\]

Inference 1 effectiveness from the rules of the existing predicate, the fuzzy boundary region is generated as follows:

\[
\mu[x] = \begin{cases} 
(x - 65)/20; & x \leq 71.67 \\
0.33; & 71.67 \leq x \leq 78.33 \\
(85-x)/20; & x \geq 78.33
\end{cases}
\]

#### 3.6 Defuzzy

Inference 1 effectiveness can be calculated using the centroid method, the calculation of the moment is as follows:

\[
M_1 = \int_{65}^{71.67} (0.05x^2 - 3.25x) \, dx
\]

\[
= 0.06167x^3 - 1.625x^2
\]

\[
= -2199.0303 + 2279.3875
\]

\[
= 80.3572
\]

\[
M_2 = \int_{71.67}^{78.33} (0.33x) \, dx
\]
= 0.165x^2
= 887.25267-847.53717
= 39.7255

\[ M_{23} = \int_{73.33}^{85} (4.25x - 0.05x^2) \, dx \]
= 2.125x^2 – 0.0167x^3
= 5097.237-4841.6518
= 255.5852

Then calculate the area of each region:
A1 = ((71.67-65) *0.33)/2 = 1.10055
A2 = (73.33-71.67) *0.33 = 0.5478
A3 = (85-73.33) *0.33 = 3.8511

Result
\[ \frac{M_1 + M_2 + M_3}{L_1 + L_2 + L_3} = \frac{80.3579 + 30.7255 + 255.5852}{80.3579 + 30.7255 + 3.05113} \]
= 67.85

The value of 67.85 is the value of the aspect of effectiveness obtained from the input of productivity access inputs, social relations, community accessibility and the isolation of citizens. Value 67.85 then classified where the value is included in the category of infrastructure development in the Normal category. Thus, the calculation of the effectiveness inference process manually, as well as the calculation of the manual inference benefit calculation process. After calculation, the results will be classified into 5 conditions. The input values entered in the program, the output of the analysis results is obtained as 1 shows 10 conditions for changes in input values that are different so that it can be seen the form of output variations generated from the simulation program that is adjusted to the input.

4. Conclusions
Analysis of the benefits of infrastructure development based on fuzzy logic can be used as one of the references in decision-making on infrastructure development in an area, supported by fuzzy logic reasoning is expected to produce accurate data. The more rules used in the inference process will produce better output. The fuzzy inference process in this application is used to determine the value of the benefit aspects and aspects of effectiveness then classify them into the boundary values of the 5 standard feasibility conditions, namely low, normal, high, very high and not feasible.

References
[1] Sri Hartati, Imas S Sitanggang, A Fuzzy Based Decision Support System for Evaluating Land Suitability and Selecting Crops Journal of computer science 6(4):417-424 2010
[2] Panduan Pelaksana PNPM PISEW TAHUN 2010
[3] Kecerdasan Buatan http://idhaclassroom.com/2007/09/15/ kecerdasan buatan.html.
[4] Suparman 2007 Komputer Masa Depan Pengenalan Artificial Intelligence
[5] Kusumadewi S 2002 Analisis Desain Sistem Fuzzy Menggunakan Tool Box Matlab, Penerbit Graha Ilmu, Yogyakarta
[6] Kusumadewi S, dan Purnomo H 2004 Aplikasi Logika Fuzzy untuk Pendukung Keputusan, Penerbit Graha Ilmu, Yogyakarta
[7] IGunaidi Abdia Away 2010 MATLAB Programming, Informatika, Bandung
[8] Kusumadewi S 2002 Analisis Desain Sistem Fuzzy Menggunakan Tool Box Matlab, Penerbit
[9] Efraim Turban, Jay E Aronson, Ting Peng Liang 2005 Decision Support System and Intelligent Systems (Sistem Pendukung Keputusan dan Sistem Cerdas) ANDI, Yogyakarta

[10] Agus Naba 2009 Belajar Cepat Fuzzy Logic menggunakan MATLAB, ANDI, Yogyakarta