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Measuring the tourist destination images based on service quality using fuzzy inference system

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ABSTRACT. The article discusses the measurement of tourist destination images perceived by travelers based on five dimensions of the service quality, i.e. tangibles, reliability, responsiveness, empathy, and assurance. Measurement problems occur when a traveller assesses the quality of a tourism destination service subjectively with vague boundaries and perceives the image of a tourism destination to vary. To address these issues, we designed an inference model using Mamdani's fuzzy inference system. The results of this study are quantitative assessments of the image of tourism destinations by various travellers based on qualitative perceptions of the quality of service experienced by the traveller.

1. Introduction

Increasing the competitiveness of the tourism industry can create new sources for regional economic growth. North Sulawesi, as a case study, has a great potential in the tourism sector which can be utilized to increase economic growth. However, from the field survey, it is found that the infrastructure, and accessibility to tourist objects are inadequate. Environmental cleanliness, tourist comfort, and safety in the tourist destinations are still far from expectations. Tourist destinations are generally not managed properly in order to look attractive and sustainably preserved. Human resources as the main players in the tourism industry, are not competent enough [1]. If these weaknesses are not properly addressed for improvements, the potential for increasing economic growth will be difficult to achieve.

The tourism industry is a very complex service industry [2], involving many players from hotel or accommodation businesses, travel agents, restaurants, food-beverage retailers, transportation businesses, the government, and local communities. All of these players serve travelers who have various expectations, experiences, lifestyles and abilities. All travelers are expected to have memorable experiences and satisfying services so they will stay longer and spend more money. To satisfy these travelers, the most important component of the tourism industry is the image of the tourist destination [3]. The image of the destination is mainly related to the quality of services carried out in an integrated and systematic manner by all tourism players. Managing the tourism service industry, which involves many players in serving the various desires and needs of the travelers, requires an integrated management system approach. One management system that can be applied is Total Quality Management. In this study, several components of TQM are considered, as the initial step of the study is limited to determining the measurement or indicator of service quality and its relation to the measurement or indicator of the image of the tourism destination. This is important to study, as it gets

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an overview of the travelers' expectations and perceptions based on their experience in some tourism objects or tourist destinations. This service quality measurement can be used by decision-makers as a monitoring and evaluation tool in improving service quality in the tourism service industry [4].

Furthermore, data which are measures or indicators of service quality experienced by travelers are generally not abundant and incompletely delivered unsystematically to tourism decision makers. Only a few travelers want to express their experiences in some tourist destinations, and, if there is, usually a few data can be conveyed. Lots of data are scattered only as a moving story. This is because there are not many officers and medias to collect the data from the traveler. If there are some data collection medias, they are only for some limited needs of the specific company, so not much data are shared for the needs of the other players [5, 6]. The data submitted by the traveler are generally subjective and qualitative, namely in the form of words or statements that are vague or inexact. Besides, with the increasing numbers of the tourists, the types and forms of the data can be variously diverse, in line with the number of the tourists [7].

2. Result and Discussion

2.1. Fuzzy Inference System

Fuzzy inference system (FIS) is a process of formulating the mapping from a given input to an output using fuzzy logic [8, 9]. The mapping provides a foundation from which decision can be made. FIS is sometimes called fuzzy reasoning, used in a fuzzy rule, to determine the rule outcome from the given rule input information. Fuzzy rules represent modelling knowledge or experience. Fuzzy rules are needed to compute the outcome for output variables in consequence of the rule when specific information is assigned to input variables in the rule antecedent. The main components of FIS include fuzzification interface, inference engine and defuzzification [9]. A basic structure of FIS comprising three components and rules can be seen in Figure 1.

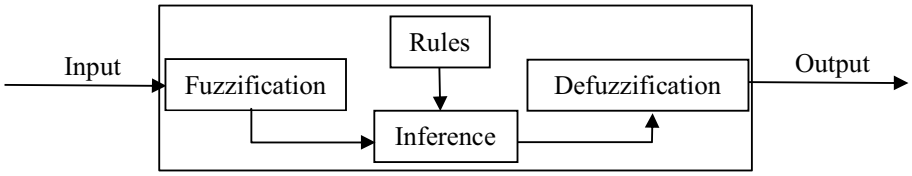


Figure 1. Basic Structure of a Fuzzy Inference System

FIS can be envisioned as involving a knowledge base and a processing stage. The knowledge base provides some membership functions and fuzzy rules needed for the process. In the processing stages, crisp numerical variables are the inputs of the system. These variables are passed through a fuzzification stage which are transformed into linguistic variables, then become the fuzzy input for the inference engine. This fuzzy input is transformed by the rules of the inference engine to a fuzzy output. A defuzzification stage, then, changes these linguistic results into numerical values that become the output of the system [9]. Creating a decision using FIS involves several steps.

The steps in FIS are created to develop an inference for the tourism destination image (output) based on service quality dimensions (input). Five dimensions of service quality, namely tangible, reliability, responsiveness, assurance, and empathy may influence the tourism destination image. In Table 1, the indicators for each dimension of the service quality and the tourism destination image are identified.

Mamdani inference system [10] allows a system to take in a set of input values, and applies a set of fuzzy rules to those values to derive a quantitative output value (Figure 2). The data from the service quality dimension become the inputs of the Mamdani inference, and the output of the system is the tourism destination image. Figure 2 illustrates the processes to transform inputs to an output.

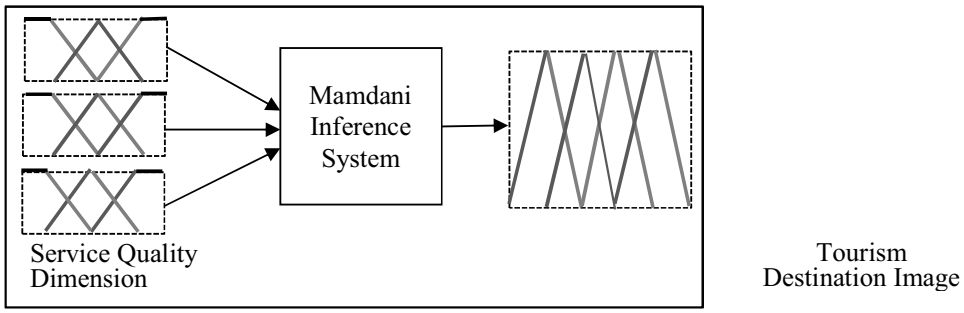


Figure 2. Transformation from the Input to the Output of the System

2.2. Output and Input of the System

The output of the inference system is the tourist destination image. Based on [11, 12], the data for the system outputs are taken from the answers to the questions according to the indicators of image, i.e. the destination environment is attractive, the tourist destinations are easy to access, the travelers enjoy the style of buildings in the destination, there is a good transportation system in the destination, the local residents of the destination are friendly, and the local residents of the destination are excellent in welcoming the travelers. The data for the system inputs are taken from the indicator of service quality dimension (Table 1), the dimension and its indicators are derived from a previous research [2, 3, 13]. The data can be collected from the back pockets of an airplane, airport waiting rooms, hotel lobbies, restaurants, tourist information offices, and some other resources, such as via questionaries' to the travelers, checklist buttons at hotels/restaurant toilets.

Based on the defined functional and operational system characteristics, the input and output data, from now on referred to as system variables are needed to fuzzify. The following steps are performed to obtain the tourist destination image based on service quality dimensions.

Table 1. Service Quality's Indicators for Input Variable

Dimension	Indicators
Tangible	The infrastructure is designed with high-quality standards.
	Modern and technologically relevant vehicles are available.
	There is enough security guards and provided security and comfort.
	The meals are of high quality.
	The accommodation and facilities are appealing and in sound design.
	The physical appearance of the hotel is tidy and clean.
	The physical appearance of the tours escort is tidy and clean.
	There is free Wi-Fi internet with large bandwidth.
	There is an adequate supply of electricity.
	There is an adequate HP charger facility.
	There are enough volunteer photographers for a selfie or groupie.
	Tourist information officers are easy to find.
Responsiveness	Tourism servicer shows sincere interest in problem-solving.
	Tourism servicer provides adequate and clear information about the service they deliver
	Tourism servicer is able to fulfil requests promptly on time.
	Tourism servicer provides full information regarding the entertainment offered.
	Tourism servicer shows sincere willingness and interest in helping/assisting.
	Tourism servicer provides advice on how to best utilize free time.
Empathy	Services offered are supplied by pleasant and friendly personnel.
	My exceptions and special needs are met as expected.
	Personal safety is considered in a significant aspect of every service provided.
	Local people care about and pay attention to traveler needs.
	Tourism destinations pay attention to the needs of disable travelers
Assurance	Well-Trained, customer-oriented personnel serves the travelers
	The level of service quality reinforces traveler's confidence in the service provided.
	Detailed, experienced, and competent tour/hotel escorts are provided to facilitate travelers.
	Staff communicates with fluently and in an understandable manner.
	All food and beverages sold are certified according to international standards.
	There is an OK sign from the results of the food and beverage audit conducted by the authorities.
	Every traveling infrastructure has been audited regularly and has passed the authorized institution.
Reliability	Directions and signs are available properly
	Directions and signs easily guide me in finding the needed locations.
	Services delivered are correct from the first time.
	Services are delivered as promised to travelers.
	Scheduled tours are on time.
	No troubles occur with the service providers during my stay.
	Information from taxi drivers/tourist information officers/hoteliers/the tour escorts is detailed, clear, and very helpful.
	Food and beverages sold are guaranteed safe and healthy.

2.3. *Fuzzy Membership Function of System Variables*

System variables are fuzzified to obtain a fuzzy membership function. The system recognizes the input and output variables and defines its membership. In this research, all membership functions for the input variables (service quality dimension) are defined in three linguistic terms, '*High'*, '*Medium'*, and '*Low'*. The output variable (tourism destination image) is defined in five linguistic terms, '*Very High'*, '*High'*, '*Medium'*, and '*Low'*, and '*Very Low'*. The experienced travelers formulate membership functions for each variable. Following are the membership functions for each variable after normalized on [0, 1] intervals. The membership functions (MF) for '*Low'*, '*Medium'*, and '*High'* fuzzy set of input variables (equation 1) are approximated by a trapezoidal function $MF_i = \mu_i(x) = tz(a, b, c, d)$, where *i={L='Low', M='Medium', H='High'},* and for output variable (equation 2) is a triangular

function $MF_j = \mu_j(y) = ta(a,b,c)$, where *j={VL='Very Low', L='Low', M='Medium', H='High', VH='Very High'}.*

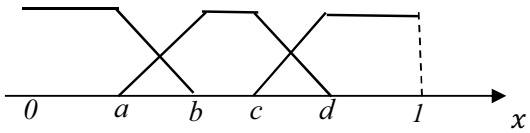


Figure 3. Membership Function for Input Variables

Where

$$\mu_L(x) = tz(0,0,a,b) = \begin{cases} 1 & 0 \le x < a \\ \frac{b-x}{b-a} & a \le x < b, \end{cases} \qquad \mu_H(x) = tz(c,d,1,1) = \begin{cases} \frac{x-c}{d-c} & c \le x < d \\ 1 & d \le x \le 1 \end{cases}$$

$$\mu_M(x) = tz(a,b,c,d) = \begin{cases} \frac{x-a}{b-a} & a \le x < b \\ 1, & b \le x < c \\ \frac{d-x}{d-c} & c \le x < d \end{cases} \quad (1)$$

For the output variable:

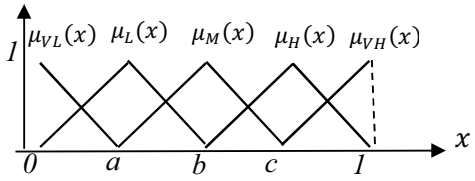


Figure 4. Membership Function for Output Variable

$$\mu_{VL}(x) = ta(0,0,a) = \frac{a-x}{a} \quad 0 \le x < a, \qquad \mu_{VH}(x) = ta(c,1,1) = \frac{x-c}{1-c} \quad c \le x < 1$$

$$\mu_L(x) = ta(0,a,b) = \begin{cases} \frac{x-a}{a} & 0 \le x < a \\ \frac{b-x}{b-a} & a \le x < b, \end{cases}$$

$$\mu_M(x) = ta(a,b,c) = \begin{cases} \frac{x-a}{b-a} & a \le x < b \\ \frac{c-x}{c-b} & b \le x \le c \end{cases}$$

$$\mu_H(x) = ta(b,c,1) = \begin{cases} \frac{x-b}{c-b} & b \le x < c \\ \frac{1-x}{1-c} & c \le x \le 1 \end{cases} \quad (2)$$

2.4. Fuzzy Rules Development

Fuzzy rules are developed from data conveyed by travelers after they visit a tourism object or a tourist destination. The forms and types of information are varied according to their different experiences, knowledge, and expectations. Fuzzy rules are defined as the *IF-THEN* rules to describe the system behavior. The rules are designed to describe the causality relationship among the indicators of service

quality dimension and the tourist destination images (equation 3).

For example:

> *IF* the direction sign for the tourism object is very clear (high) *AND* the highway infrastructure is very good (high), *AND* the tourism destination is very comfortable (high) *THEN* the traveler will give a positive image of the tourism destination (very high).

In general, the travelers' ratings can be stated based on several dimensions of service quality, as follows:

> *IF* an *tangible* indicator is 'fuzzy set *i*' *AND* an *reliability* indicator is 'fuzzy set *j*' *AND* ⋯ *THEN the image of a tourism destination* is 'fuzzy set *k*'. (3)

Where fuzzy set *i, j* can be categories as '*Low'*. '*Medium'*, or '*High'*, while the fuzzy set *k* of output variable can be categories as '*Very Low*', '*Low'*. '*Medium'*, '*High'*, or '*Very High*'.

Rules

Rules Display

Rule	Active	IF Tangible	AND Reliability	AND Responsiveness	AND Assurance	AND Empathy	THEN Image
1	☑	MF1	MF1	MF1	MF1	MF1	MF1
2	☑	MF1	MF1	MF1	MF1	MF2	MF1
3	☑	MF1	MF1	MF1	MF1	MF3	MF2
4	☑	MF1	MF1	MF1	MF2	MF1	MF1
5	☑	MF1	MF1	MF1	MF2	MF2	MF2
6	☑	MF1	MF1	MF1	MF2	MF3	MF2
7	☑	MF1	MF1	MF1	MF3	MF1	MF2
8	☑	MF1	MF1	MF1	MF3	MF2	MF2
9	☑	MF1	MF1	MF1	MF3	MF3	MF3
10	☑	MF1	MF1	MF2	MF1	MF1	MF1
11	☑	MF1	MF1	MF2	MF1	MF2	MF2
12	☑	MF1	MF1	MF2	MF1	MF3	MF2
13	☑	MF1	MF1	MF2	MF2	MF1	MF2
14	☑	MF1	MF1	MF2	MF2	MF2	MF2
15	☑	MF1	MF1	MF2	MF2	MF3	MF3
16	☑	MF1	MF1	MF2	MF3	MF1	MF2
17	☑	MF1	MF1	MF2	MF3	MF2	MF3
18	☑	MF1	MF1	MF2	MF3	MF3	MF3
19	☑	MF1	MF1	MF3	MF1	MF1	MF2
20	☑	MF1	MF1	MF3	MF1	MF2	MF2
21	☑	MF1	MF1	MF3	MF1	MF3	MF3
22	☑	MF1	MF1	MF3	MF2	MF1	MF2
23	☑	MF1	MF1	MF3	MF2	MF2	MF3
24	☑	MF1	MF1	MF3	MF2	MF3	MF3
231	☑	MF3	MF3	MF2	MF2	MF3	MF4
232	☑	MF3	MF3	MF2	MF3	MF1	MF4
233	☑	MF3	MF3	MF2	MF3	MF2	MF4
234	☑	MF3	MF3	MF2	MF3	MF3	MF5
235	☑	MF3	MF3	MF3	MF1	MF1	MF3
236	☑	MF3	MF3	MF3	MF1	MF2	MF4
237	☑	MF3	MF3	MF3	MF1	MF3	MF4
238	☑	MF3	MF3	MF3	MF2	MF1	MF4
239	☑	MF3	MF3	MF3	MF2	MF2	MF4
240	☑	MF3	MF3	MF3	MF2	MF3	MF5
241	☑	MF3	MF3	MF3	MF3	MF1	MF4
242	☑	MF3	MF3	MF3	MF3	MF2	MF5
243	☑	MF3	MF3	MF3	MF3	MF3	MF5

Figure 5. Fuzzy Rules of the System

As a simulation, each dimension of service quality (input) uses an indicator and the tourist destination image (output) is expressed as an indicator. Table 5 shows 243 fuzzy rules that are obtained from all possible indicators for service quality dimensions and an indicator for a tourist destination image. To shorten each fuzzy set, it is used MF1=*Low*, MF2=*Medium*, and MF3=*High* for input variables (service quality dimension), and for output variable (Image) MF1=*Very Low*, MF2=*Low*, MF3=*Medium*, MF4=*High*, and MF5=*Very High*.
Example of fuzzy rule:

Rule 1: *IF* an indicator in the tangible dimension is *Low AND* an indicator in the reliability dimension is *Low AND* an indicator in the responsiveness dimension is *Low AND* an indicator in the

assurance dimension is *Low AND* an indicator in the empathy dimension is *Low THEN* the tourism destination image will be *Very Low*.

⋮

Rule 24: *IF* an indicator in the tangible dimension is *Low AND* an indicator in the reliability dimension is *Low AND* an indicator in the responsiveness dimension is *High AND* an indicator in the assurance dimension is *Medium AND* an indicator in the empathy dimension is *High THEN* the tourism destination image will be *Medium*.

The inference rules set the premise to create an output, then the output needs to defuzzify to obtain a crisp value.

2.5. Defuzzification

Defuzzification step is needed to convert all input data into three linguistic terms (*Low, Medium*, or *High*) that can be used to observe the tourist destination images (*Very Low, Low, Medium, High,* or *Very High*). The defuzzification process transforms the fuzzy set into the crisp value that is meaningful to the decision maker.

Figure 6 shows the results of inference of 243 *IF-THEN* rules. Based on the crisp value of each dimension of the service quality, fuzzification is done into a red fuzzy set according to the corresponding fuzzy set, then connected with the *AND* logic which is operationalized with the *MIN* operator.

$$\mu_{A_1}(x) \cap \mu_{A_2}(x) \cap \cdots \cap \mu_{A_n}(x) = MIN[\mu_{A_1}(x), \mu_{A_2}(x), \cdots, \mu_{A_n}(x)] \quad (4)$$

Where $A_1, A_2, \cdots, A_n$ are fuzzy set for indicators of each service quality dimension.

Furthermore, the combination of all rules is operationalized with logic *OR* or *MAX*, the result is a total fuzzy set that describes the resulting image.

$$\mu_{B_1}(y) \cup \mu_{B_2}(y) \cup \cdots \cup \mu_{B_m}(y) = MAX[\mu_{B_1}(y), \mu_{B_2}(y), \cdots, \mu_{B_m}(y)] \quad (5)$$

Where $B_1, B_2, \cdots, B_m$ are fuzzy set for tourism destination image as a result of each rule.

Finally, defuzzification is performed by calculating the center point or centroid, resulting in a tourist destination image in the form of crisp number, i.e. a quantitative score between [0, 1].

$$Centroid = \frac{\int_0^1 \mu_B(y) y dy}{\int_0^1 \mu_B(y) dy} \quad (6)$$

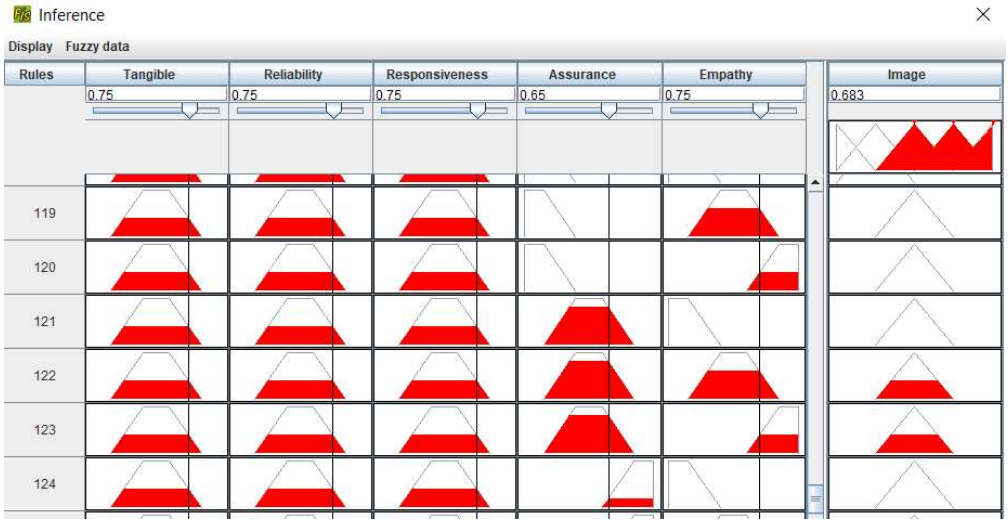


Figure 6. Inference of 243 Rules

Figure 6 can be used as a detection and monitoring tool by decision-makers, who are engaged in the tourism industry, to find out the image of the tourist services provided based on the quality of tourist destination services, which are expressed by travelers from their experiences and expectations.

Based on the 243 fuzzy rules above, the simulation can be done to determine the impact of changes in each indicator of the service quality on the image of a tourist destination. From these simulations, it can be inferred which indicator has a significant impact on improving the image of the tourist destinations. Furthermore, changes can also be seen in 3 dimensions or 2 dimensions (Figure 7). As an example, the changes in the image of tourist destinations can be observed due to changes in an indicators of tangible and reliability dimensions, when other indicators of the service quality are constant. It appears that, when services on the tangible and reliability dimensions increase, the image also increases.

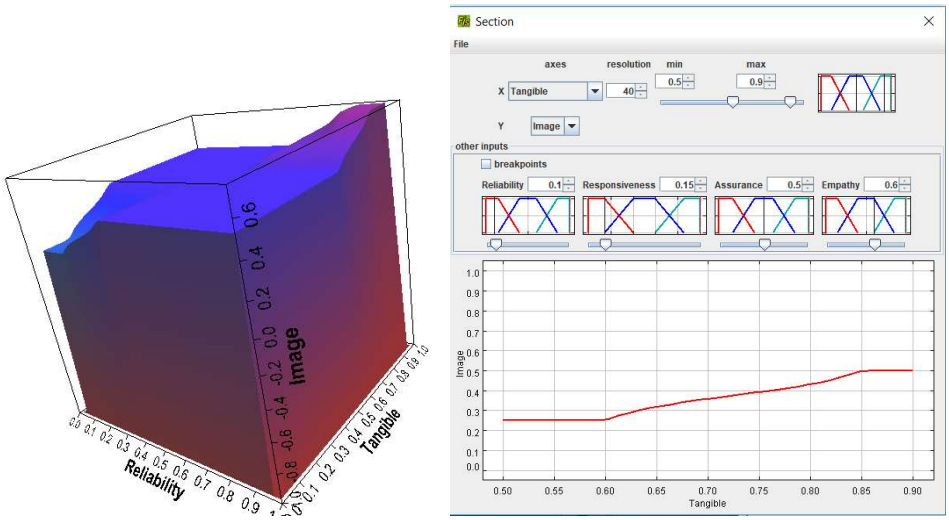


Figure 7. Visualize The Tourism Destination Image in 3D and 2D

3. **Conclusion**

The image of the tourist destinations is important in increasing the number of travelers to visit. Increasing visitors have an impact on the regional economic growth of the tourism area. The increased tourist destination image is a strategic effort that must be carried out by all tourism players. One of the efforts to improve the image is by improving the service quality. To find out the service quality that needs to be prioritized, it is compulsory to understand the indicators of the service quality. This initial research has identified several measures/indicators that are in line with the tourist destination services. This study also produces reasoning rules to improve the image of the tourist destinations based on several indicators of the service quality dimensions using a fuzzy inference system. This research is still in the early stage, and there are several weaknesses, as it has not yet produced reasoning rules using all possible indicators of the service quality dimensions. In the future, it needs to be developed continuously the reasoning rules resulting from interviews or direct observation of travelers or from data collection of various social medias. Then, it needs to be integrated automatically with government-owned information systems, and distributed to tourism players in real time through online media.

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