Smart City Application: Community Survey System of Urban Comfort Level

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Abstract. Based on the projected increase in urban population in Indonesia released by the Ministry of PUPR and Bappenas in 2017 that there was a significant increase in urbanization, which is estimated that in 2015-2035 the population in urban areas will exceed the population in rural areas (66.6% of the population urban and 33.4% rural population). Increasing the number of the urban population needs to get proper handling from the government. If not, it will trigger the emergence of various urban problems ranging from the physical city to the problems that will have an impact on the reduced level of comfort in life in the region. Based on this, it is necessary for the participation of city dwellers in playing the role of planners, actors, and supervisors of city development. This research work develops a framework which uses fuzzy Inference System to calculate urban comfort level, starting from a questionnaire-based survey. There are seven input variables used to produce an output of urban comfort level. Based on the stages of using the Mamdani Model Fuzzy Inference Logic System starting from the formation of the fuzzy set, the application of the impulse function, the composition of the rules to the process of affirmation (defuzzification), it can be proven that there is a correlation between the input variables so that it can determine the output of urban comfort level results. The outcomes help the city government in making public policy on city development.

1. Introduction

The development of cities has historically been seen as causes and solutions for social, economic, political and cultural improvement. However, in the development of the city, the environment changes. Environmental changes are influenced by the level and type of industrialization, the quality of housing, accessibility to green spaces and raising concerns about transportation [1]. Environmental damage is a problem of the city caused by the city development that affects large-scale urbanization in the city.

The increasing population continues to make the city services will be increasingly ineffective unless the city can provide the necessary service facilities for the community as a whole who live in the city. Today many cities throughout the world still cannot serve the people who live in it. This is because the city cannot provide infrastructure service facilities to accommodate daily community activities in the city. So many urban people no longer feel comfortable living in cities, due to overcrowding that makes city spaces more narrow, congestion, and environmental damage.

From the problems of the city above, the city community needs a city that is livable for them or called Livable City. Livable City is a keyword in urban planning because it can solve various city problems that disturb the comfort of the city. By increasing the quality of life that people living in cities are related to their ability to access infrastructure (transportation, communication, water, and sanitation), food, clean air, affordable housing, employment and space, and green parks. The Livable City concept
infrastructure in sustainable city representation [2]. In the context of sustainability is the ability to maintain the quality of life required by the city community.

Conditions in the future will be even more uncomfortable if there are no bold, creative, and progressive actions from city leaders to take and implement bold city development policies, likewise, with the residents. The community must understand, understand and carry out their obligations as a good city citizen, not just being a city community but becoming a city citizen (citizen) who helps realize the comfort of the city. City residents must also play a role as planners, actors, and supervisors of city development. In this decade, citizen participation in the process of urban development planning has become a strategic matter in changing and formulating public policies on urban development. The city government and community must unite in collaboration to realize the livable city of Indonesia's Future.

Fuzzy logic is one method for analyzing systems that contain uncertainty. Fuzzy Mamdani is one method that is very flexible and has a tolerance on existing data. Fuzzy Mamdani has the advantage of being, more intuitive, accepted by many parties, more suitable input received from humans, not machines. Based on fuzzy logic, a Mamdani fuzzy model will be produced that can analyze the comfort level of the city.

2. Literature Review

2.1. Definition of Livable City

Nowadays, many urban people are complaining about the inconvenience of their neighborhood. These inconveniences can be found in problems ranging from traffic jams, poor maintenance of public facilities, and environmental cleanliness issues. In these conditions, every community wants a city that is comfortable and deserves to be inhabited or Livable City. "A Livable City is a city where I can have a healthy life and where I have the chance for easy mobility - by foot, by bicycle, by public transportation, and even by car where there is no other choice ... Livable City is a city for all people. That means that the Livable City should be attractive, worthwhile, safe for our children, for our older people, not only for the people who earn money there and then go and live outside in the suburbs and the surrounding communities. For the children and older people, it is especially important to have easy access to areas with green, where they have a place to play and meet each other, and talk with each other. Livable City is a city for all [3]."

A livable city or Livable City is where people can live comfortably and quietly in a city. A livable city is a city that can accommodate all the activities of the city community and is safe for all people [4]. The concept of Livable City is used to realize that the idea of development as an improvement in the quality of life requires both physical and social habitat for its realization [5].

In realizing the concept of Livable City, it must be supported by sustainable cities, so that urban space planning can be realized according to plan. In the context of sustainability is the ability to maintain the quality of life that is needed by current and future urban communities. "Therefore a Livable City is also a 'sustainable city': a city that satisfies the needs of the present inhabitants without reducing the capacity of the future generation to satisfy their needs" [6]. Livable City is a city where public spaces are the center of social life and focus throughout the community [6]. The concept of Livable City is used to realize that the idea of development as an improvement in the quality of life requires both physical and social habitat for its realization [7].

"... there are those social groups for whom a Livable City is one where those elements have been preserved or renewed which have always been an integral part of people-friendly places. These are, as Peter Smithson once beautifully said ‘relationships between streets and buildings, and buildings between themselves, and trees, and seasons of the year, and ornamentation, and events and other people [8]."

The Livable City concept is also very much related to the environment. Livable City must be sustainable with the ecological system and the comfort of life for the city community. Ecological recovery can improve the environment in Livable City and sustainability. Livable City must create and maintain a clean environment. "The coin of livability has two faces. Livelihood is one of them. Ecological sustainability is the other. Livelihood means jobs close enough to decent housing with wages commensurate with rents and access to services that make for a healthful habitat. Livelihoods must also
be sustainable. If the quest for jobs and housing is solved in ways that progressively and irreparably degrade the environment of the city, then the livelihood problem is not being solved. Ecological degradation buys livelihood at the expense of quality of life, with citizens forced to trade green space and breathable water for wages. To be livable, a city must put both sides of the coin together, providing livelihoods for its citizens, ordinary as well as affluent, in ways that preserve the quality of the environment [9].

Understanding Livable City from the perspective of people is a livable city where urban people can find work, serve basic needs including clean water and sanitation, have access to proper education and health, live in a safe community and a clean environment. It can be said that Livable City is a description of a comfortable environment and atmosphere of the city as a place to live and as a place for activities seen from various aspects, both physical aspects (urban facilities, infrastructure, spatial planning, etc.) as well as non-physical aspects (social relations, economic activity, etc.).

2.2. Livable City Principles

In realizing a livable city, Livable City must have basic principles. This basic principle must be owned by cities that want to make the city a livable and comfortable city for the people of the city. The following are the basic principles for realizing Livable City:

1. The basic principles for Livable City [8]
   a. Availability of various basic needs of urban communities (decent housing, clean water, electricity).
   b. Availability of various public and social facilities (public transportation, city parks, worship facilities/health/ worship services).
   c. Availability of public spaces and places for socializing and interacting.
   d. Security, free from fear.
   e. Supports economic, social and cultural functions.
   f. Environmental sanitation and physical beauty.

2. In Livable City, can be said to rest on 4 (four) pillars [10]
   a. Improve the system of life opportunities for the welfare of society.
   b. Provision of employment.
   c. A safe and clean environment for health, well-being and for sustaining economic growth.
   d. Good governance.

2.3. Livable City Case Study in Indonesia

To find out the perceptions of city residents regarding the comfort level of big cities in Indonesia, the Indonesian Planning Experts Association (IAP) conducted a 2011 Indonesia Most Livable City Index (MLCI) research. This activity is an annual index that shows the comfort level of city residents to live, live and activities in a city in terms of various aspects of urban areas. This index is produced with the following approaches: "Snapshot, Simple and Actual" conducted in 15 major cities in Indonesia, namely Yogyakarta, Denpasar, Makassar, Surabaya, Semarang, Banjarmasin, Batam, Jayapura, Bandung, Palembang, Palangkaraya, Jakarta, Pontianak, and Medan. The indicator criteria used by IAP in conducting this research consisted of 26 indicators which were grouped into several main criteria [9], namely:

1. The Spatial Aspect (Urban Planning, Green Open Space),
2. Environmental Aspects (Cleanliness, Pollution),
3. Transportation Aspects (Roads, Transportation),
4. The Health Facilities Aspect,
5. Educational Facility Aspects,
6. Infrastructure Aspects - Utilities (Electricity, Water, Telecommunications),
7. Economic Aspects (Field of Work, Location of Work),
8. Security Aspects,
9. Social Aspects (Culture, Citizen Interaction).
2.4. Fuzzy Logic

The concept of fuzzy logic was introduced by Prof. Lotfi Astor Zadeh in 1962. Fuzzy logic is a methodology of problem-solving control systems that is suitable for implementation on systems, ranging from simple systems, small systems, PC networks, multi-channel or workstations based on data acquisition, and control systems. In fuzzy logic it allows membership values to be between 0 and 1 [11].

According to Kusumadewi and Purnomo said, "Fuzzy logic is one of the components forming soft computing". Prof. Lotfi A. Zadah first introduced fuzzy logic in 1965. The basis of fuzzy logic is fuzzy set theory. In fuzzy set theory, the role of the degree of membership as a determinant of the existence of elements in a set is very important [10].

Sutojo et al. said "Fuzzy logic is a methodology of problem-solving control systems, which is suitable for implementation on systems, ranging from simple systems, small systems, embedded systems, PC networks, multi-channel or workstations based on data acquisition, and control systems. This methodology is applied to hardware, software, or a combination of both [12].

2.5. Mamdani Model Fuzzy Inference System Logic

The Fuzzy Inference System Mamdani model is often also known as the max-min method. Ebrahim Mamdani introduced this method in 1975. The Mamdani method is often used in applications because of its simple structure, which uses MIN-MAX or MAX-PRODUCT operations [10]. To get the output, four stages are needed, namely:

a. Fuzzy set formation.
   In the Mamdani Method, both input and output variables are divided into one or more fuzzy sets.

b. Application function implications.
   In the Mamdani Method, the implication function used is Min.

c. Rule Composition
   Unlike monotonous reasoning, if the system consists of several rules, then the inference is obtained from the collection and correlation between rules. There are 3 methods used in conducting fuzzy system inferences, namely: max, additive and probabilistic OR (probe)

d. Affirmation (defuzzification)
   The input of the defuzzification process is a fuzzy set obtained from the composition of fuzzy rules, while the resulting output is a number in the fuzzy set domain. So if given a fuzzy set within a certain range, then a certain crisp value can be taken as output.

3. Result and Discussion

3.1. Fuzzy Set Formation (Fuzzification)

The process of determining the assessment of city comfort levels has seven input variables and one output variable. Input variables consist of physical, environment, economic, transportation, facilities, infrastructure and social. The output variable to be processed is the city comfort variable.

| Function Name | Variable         | Universe Talks | Description      |
|---------------|------------------|----------------|------------------|
| Input         | Physical city    | [1 10]         | Rating Points    |
|               | environmental    | [1 10]         | Rating Points    |
|               | Quality          | [1 10]         | Rating Points    |
|               | Transportation   | [1 10]         | Rating Points    |
|               | Facilities       | [1 10]         | Rating Points    |
|               | Infrastructure   | [1 10]         | Rating Points    |
|               | Economy          | [1 10]         | Rating Points    |
|               | Social           | [1 10]         | Rating Points    |
| Output        | urban comfort level | [1 10]     | Rating result    |
In the process of producing values from the output variables, four stages are needed, namely the formation of fuzzy sets (fuzzification), the application of implication functions, the composition of rules to the affirmation process (defuzzification). Details of the data can be seen in Table 1.

Table 2. Fuzzy association

| Variable Name          | Fuzzy Association | Domain     | Membership function |
|------------------------|-------------------|------------|---------------------|
| Physical city          | Not good          | [ 1 4]     | Left shoulder       |
|                        | Pretty good       | [ 3 6]     | Trapezoidal         |
|                        | Well              | [ 5 8]     | Trapezoidal         |
|                        | Very good         | [ 7 10]    | Right shoulder      |
|                        | Not good          | [ 1 4]     | Left shoulder       |
| Environmental quality  | Pretty good       | [ 3 6]     | Trapezoidal         |
|                        | Well              | [ 5 8]     | Trapezoidal         |
|                        | Very good         | [ 7 10]    | Right shoulder      |
|                        | Not good          | [ 1 4]     | Left shoulder       |
| Transportation         | Pretty good       | [ 3 6]     | Trapezoidal         |
|                        | Well              | [ 5 8]     | Trapezoidal         |
|                        | Very good         | [ 7 10]    | Right shoulder      |
|                        | Not good          | [ 1 4]     | Left shoulder       |
| Facilities             | Pretty good       | [ 3 6]     | Trapezoidal         |
|                        | Well              | [ 5 8]     | Trapezoidal         |
|                        | Very good         | [ 7 10]    | Right shoulder      |
|                        | Not good          | [ 1 4]     | Left shoulder       |
| Economy                | Pretty good       | [ 3 6]     | Trapezoidal         |
|                        | Well              | [ 5 8]     | Trapezoidal         |
|                        | Very good         | [ 7 10]    | Right shoulder      |
|                        | Not good          | [ 1 4]     | Left shoulder       |
| Social                 | Pretty good       | [ 3 6]     | Trapezoidal         |
|                        | Well              | [ 5 8]     | Trapezoidal         |
|                        | Very good         | [ 7 10]    | Right shoulder      |
|                        | Not good          | [ 1 4]     | Left shoulder       |
| Comfort Urban Level    | Pretty good       | [ 3 6]     | Trapezoidal         |
|                        | Well              | [ 5 8]     | Trapezoidal         |
|                        | Very good         | [ 7 10]    | Right shoulder      |

The graph of representation of the degree of membership of the fuzzy set of town comfort ratings is as follows:

a. Graphic representation of the degree of membership of physical city variables

![Figure 1. Degree of membership in physical city variables](image_url)
b. Graphic representation of the degree of membership of environmental quality variables

![Figure 2. Degree of membership of environmental quality variables](image)


c. Graphic representation of the degree of membership of transportation variable

![Figure 3. Variable transportation membership degree](image)

d. Graphic representation of the degree of membership of variable facilities

![Figure 4. Degree of membership of variable facilities](image)

e. Graphic representation of the degree of membership of the infrastructure variable

![Figure 5. Variable infrastructure membership degrees](image)
f. Graph representation of the degree of membership of economic variables

![Graph of economic variables](image)

**Figure 6.** Degree of membership of economic variables

g. Graph representation of the degree of membership of social variables

![Graph of social variables](image)

**Figure 7.** Degrees of membership of social variables

h. Graphic representation of the degree of membership in urban comfort level variables

![Graph of urban comfort](image)

**Figure 8.** Degrees of membership in urban comfort level variables

### 3.2. Application function Implications

Rules can be formed to express the relationship between input variables and output variables. Every rule is an implication. The operator used to connect the two inputs is AND, and the one that maps between input variables and output variables is IF-THEN. The rules include:

**Rule 1:** if (physical city is not good) and (environmental quality is not good) and (transportation is not good) and (facilities are not good) and (infrastructure is not good) and (economy is not good) and (social is not good) then (urban comfort level is not comfortable)

**Rule 2:** if (physical city is not good) and (environmental quality is not good) and (transportation is not satisfactory) and (facilities are not satisfactory) and (infrastructure is not good) and (economy is not good) and (social is Pretty Good) then (urban comfort level is Uncomfortable)

**Rule 3:** if (physical city is not good) and (environmental quality is not quality) and (transportation is not satisfactory) and (facilities are not satisfactory) and (infrastructure is not good) and (economy is not good) and (social is OK) then (urban comfort level is Not comfortable)
Rule 4: if (physical city is not good) and (environmental quality is not good) and (transportation is not good) and (facilities are not good) and (infrastructure is not good) and (economy is good enough) and (social is not good) then (urban comfort level is not comfortable)

Rule 5: if (physical city is not good) and (environmental quality is not good) and (transportation is not good) and (facilities are not good) and (infrastructure is not good) and (economy is good enough) and (social is Pretty Good) then (urban comfort level is Uncomfortable)

Rule 6: if (physical city is good enough) and (environmental quality is good enough) and (transportation is good enough) and (facilities are good enough) and (infrastructure is good enough) and (economy is good enough) and (social is Pretty Good) then (urban comfort level is Comfortable enough)

Rule 7: if (the physical city is Good) and (environmental quality is Good) and (transportation is Good) and (facilities is Good) and (infrastructure is Good) and (economy is Good) and (social is Good) then (urban comfort level is comfortable)

etc…..

3.3. Composition of Fuzzy rules

In the Mamdani method, the composition between functions implies using MAX by taking the maximum value from the rule output, then combining each fuzzy area.

3.4. Defuzzification Process

The process of defuzzification is to convert the fuzzy output to a firm value based on a predetermined membership function. The defuzzification process uses the Centroid Method.

4. Conclusion

The result shows that using the fuzzy Mamdani model can explain the rules of connectedness between input variables namely physical city, environment, economic, transportation, facilities, infrastructure, and social aspects to produce an output of the city comfort level. This research has proven the correlation of these variables in determining the results of the city comfort level.

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