Smart City Feature Using Six European Framework and Multi Expert Multi Criteria: A Sampling of the Development Country

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Summary
Continuous development is the key of development issue in developing nations. Smart city measurement is prevalently carried through in the cities in which the nations have been classified as industrialized countries. In addition, cities in Europe becomes the models of smart city system. Smart city concept used in the cities in Europe applies six predominant features i.e. smart economic, smart mobility, smart environment, smart people, smart living, and smart governance. This paper focuses on figuring out city' development strategy in developing nations particularly Indonesia in regard with European Framework by way of Multi Expert Multi Criterion Decision Making (ME-MCDM). Recommendation is resulted from the tests using the data collected from one of the metropolis cities in Indonesia, whereby issuing recommendation must firstly implement smart education, secondly communication, thirdly smart government, and fourthly smart health, as well as simultaneously implement smart energy and smart mobility.

Keywords:
six feature, me-mcdm, smart city

1. Introduction

There are six predominant features in the concept of smart city that are interrelated including smart health, smart education, smart mobility, smart energy, smart governmental (smart economy, smart people, smart environment, smart living), smart telecommunication applied to cities in European countries [1]–[7]. This key feature becomes the stages in implementing intelligent systems by looking at all the problems that occur in a city [8]–[12]. Smart city feature has been implemented in cities in developed countries, because it is the development of a city that continues to grow as a center of government and social activities, also focused on how big the value of cities that implement these six features [1], [2], [13]–[17]. The concept of smart city can control and integrate all infrastructure including roads, bridges, tunnels, railways, subways, airports, ports, communications, water, electricity, and building management, so that business processes run well [18]–[23].

Research on 70 cities in European countries was conducted and measured the value of each feature in order to produce a city ranking. Measuring six main features of smart cities including smart economy, smart mobility, smart environment, smart people, smart life, and smart governance, these measurements are based on the indicator values of each main features [19], [24]–[30]. The purpose of this evaluation is to compare characteristics and identify the edges and disadvantages of cities that have implemented six main features of smart cities, so that information about the current condition of the city has been obtained. Meanwhile, the low value of features will be improved through more innovative development [26], [31]. The six main features are the main parameters of smart cities that have been applied in developed countries, especially in European cities. This is quite easy to implement because of the availability of complete and adequate infrastructure. Therefore, measuring the results of implementation is not difficult, because the system has been implemented and has been enjoyed by the city community.

However, this will be different if applied to urban developing cities where urbanization from rural to urban areas is the biggest problem, so cities are a mixing place for all types of people from various groups but are not prepared with all the facilities that must be provided. So the use of smart cities is not directly as an already running system but is an alternative system that will be used to build smart cities so that they can provide effective, convenient and good services [5], [29], [32].

In this paper, the highlighted part is the significant difference between developing and developed cities in implementing the features of the European smart city framework, where differences in human resources, infrastructure and urban issues are found. Cities in Europe do not have a problem about infrastructure because it has been built since tens of years ago, as well as human resources have been adequate because the average has gone to higher education [33]. Both of the above-mentioned

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statements will be the solutions of any emerging city problems, because the city has facilitated everything in connection with the needs of urban society. In cities of developing countries especially in Indonesia, infrastructure and human resources are problems in every development and development of the region, where the formation of the city is not necessarily coupled with the readiness of infrastructure and adequate resources, because the city will be formed if the population has many or in accordance with what the national statistics bureau stipulates [34], [35]. So if an area has a lot of population then the area can be converted into a small town or middle town. Smart city concept is a research that focuses on the principal features of smart city [2], [9]. The main features in question are the areas that became the focus of the problem in general cities around the world. Smart city concept includes 6 features of smart health, smart education, smart mobility, smart energy, smart governmental (smart economy, smart people, smart environment, smart living), smart telecommunication. Research focusing on smart city concept is intended to help the application of smart city in cities in developing countries like Indonesia to become a standard pattern in building the city. In this paper, we will describe the application of multi expert multi criteria decision making (MEMCDM) to measure the data of city in Indonesia so that it can be known the recommendation of development based on the main feature of smart city.

2. Research design

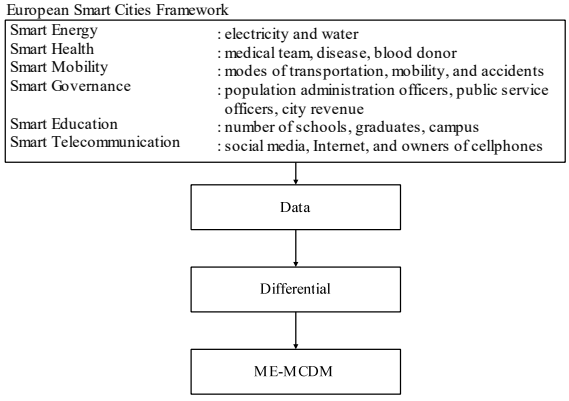

Fig. 1. Research design framework

2.1 Smart Cities: Concept and Features

The definition of smart city in many literatures has various meanings, and one of them is the use of technology to build the city so that it can advance in all fields and to restore the relationship between human, built space and more harmonious natural space, so that will form a more humane and natural. But the notion of smart city is still limited to cities in developed or industrialized countries because it has been implementing the development since long ago using smart city-based, different in the existing city in developing countries like Indonesia, because its base from the beginning is only power-based development [13], [17]. So the availability and quality of inadequate information technology infrastructure becomes a very significant constraint when doing smart city-based development. Smart cities are adopted from developed countries or industries, especially European countries, where within the framework of this smart city has 6 main features in which there are also parameters. And here are 6 main features as a framework in the application of smart cities, namely smart health, smart education, smart mobility, smart energy, smart governmental (smart economy, smart people, smart environment, smart living), smart telecommunication [1], [2].

In Indonesia, with the Law No. 32 of 2004 concerning cities or territories, cities are given their rights, powers and duties as autonomous regions, so that they can regulate and manage their own government affairs and the interests of local communities in accordance with applicable laws and regulations. The purpose of autonomy over an area is to be increasingly responsive to the government in serving its people. This is in accordance with the smart city system that is responsive to all fields needed by the public **[36].**

However, the problem of the city today is the disproportionate concentration of the distribution of population domicile, so that the imbalance of population distribution between one area and another, the population distribution settings are not optimal enough **[15], [24].** In addition, traffic and transportation problems, irregular buildings, wasteful use of energy, unhealthy living environments and poor governance are serious problems faced by many city governments **[37]**.

In this paper, the European smart cities framework is adopted nevertheless not all indicators are exploited because it adjusts the conditions of Indonesian cities. Hence, the data parameters used are included (1) Smart energy: The indicators are electricity and water; (2) Smart health: The indicators are medical team, disease, blood donor; (3) Smart mobility: The indicators are modes of transportation, mobility, and accidents, (4) Smart governance: The indicators are population administration officers, public service officers, city revenue; (5) Smart education: The indicator is the number of schools, the number of graduates, campus; and (6) Smart telecommunications: The indicators are social media, internet, and owners of communication devices (cellphones).

Furthermore, the identified data will be calculated using the differential equation formula, because it refers to the city definition where the parameter used is population. Therefore, the calculation formula on the six smart city features is adjusted in alternatives and criteria.

In this study, data was collected from the Central Statistics Agency (BPS), the Republic of Indonesia, which conducts surveys annually in all cities and districts. The data will be calculated using the formula above and adjusted for the main features and also multi-criteria according to the multi-expert multi-criteria decision making method (ME-MCDM).The focus of this paper is how to obtain implementation recommendations using the terms of reference applied in Europe by using the multi-expert multi-criteria decision making method (ME-MCDM) in Indonesian cities. This discussion is very important because the facts in the field of smart city systems in Indonesian cities are less focused or not even focused on implementation, so smart city systems which should bring significant progress but become a burden. With a good understanding, the implementation of smart city-based development must bring progress to the quality of life of urban communities so that they can be aligned with cities in developed countries.

2.2 ME-MCDM Processing

The first stage of a multi-expert multi-criteria decision-making method is to determine alternatives and criteria and identify the rating scale to be used. The rating scale serves to assign a value to each alternative according to existing criteria. Second, the assessment of several experts, in this research there were five experts from the Central Statistics Agency (BPS), the Republic of Indonesia who completed. The expert scores results are arranged in a table called the expert rating matrix, as shown in Table 1.

Table 1. Determining Alternative and Criteria

Alternatives	Criteria	Features
Alt1	C1	Smart Energy
Alt2	C2	Smart Health
Alt3	C3	Smart Mobility
Alt4	C4	Smart Government
Alt5	C5	Smart Education
Alt6	C6	Smart Telecommunication

Alternatives are criteria derived from each smart city feature, and each feature has different criteria that are adjusted to the data obtained. In this study, criteria as an alternative in experimental calculations can be seen in Table 2.

Table 2. The Criteria of Each Feature

ALT	Criteria									
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
1	Population administration	State employee	Regional revenue	-	-	-	-	-	-	-
2	Economics/business	Agriculture	Farm	Fishery	Factory	School	Hotels	Hospitals	Worship place	Government office
3	Number of medical personal	Diseases	Blood donors	-	-	-	-	-	-	-
4	Means of transportation	Mobility	Accident	-	-	-	-	-	-	-
5	Electricity	Water	-	-	-	-	-	-	-	-
6	Graduated from university	Schools	University	-	-	-	-	-	-	-

Table 3. Expert judgment matrix

Expert	ALT	CRITERIA									
		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Exp. 1	Alt1	I	I	VI	NULL	NULL	NULL	NULL	NULL	NULL	NULL
	Alt2	VI	VI	VI	MI	MI	NI	NU	VI	VI	VI
	Alt3	NI	NI	MI	NULL	NULL	NULL	NULL	NULL	NULL	NULL
	Alt4	NTI	NTI	MI	NULL	NULL	NULL	NULL	NULL	NULL	NULL
	Alt5	VI	VI	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
	Alt6	VAE	VAE	VAE	NULL	NULL	NULL	NULL	NULL	NULL	NULL
Exp. 2	Alt1	I	MI	VI	NULL	NULL	NULL	NULL	NULL	NULL	NULL
	Alt2	I	I	VI	VI	MI	NTI	VU	AE	AE	AE
	Alt3	VU	NI	MI	NULL	NULL	NULL	NULL	NULL	NULL	NULL
	Alt4	NTI	NTI	MI	NULL	NULL	NULL	NULL	NULL	NULL	NULL
	Alt5	MI	MI	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
	Alt6	VAE	VAE	VAE	NULL	NULL	NULL	NULL	NULL	NULL	NULL
Exp. 3	Alt1	I	MI	MI	NULL	NULL	NULL	NULL	NULL	NULL	NULL
	Alt2	I	I	VI	VI	MI	NTI	VU	AE	AE	AE
	Alt3	NTI	NTI	MI	NULL	NULL	NULL	NULL	NULL	NULL	NULL
	Alt4	VI	VI	MI	NULL	NULL	NULL	NULL	NULL	NULL	NULL
	Alt5	AE	AE	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
	Alt6	VAE	VAE	VAE	NULL	NULL	NULL	NULL	NULL	NULL	NULL

In this study, rating scales according to several experts have been used including Very Absolutely Essential (VAE), Absolutely Essential (AE), Very Important (VI), More Important (MI), Important (I), Not Too Important (NIT), Not Important (NI), Very Unimportant (VU) with 8-1 of scoring scale.

Where, these criteria and weights are very important in getting an expert judgment matrix. The goal is to calculate the priority components for each use of smart city features. Based on this, an expert judgment matrix has been obtained and can be seen in Table 3.

The assessment from experts is determined from the relationship of each data obtained and adapted to the existing criteria. Table 3, the relationship of each alternative with the number of each criterion have been acquired. There are a maximum of 10 criterion on each alternative, but not all alternatives have maximum criteria. This is related to data from each city that is not the same so that the level of interest criteria tailored to the opinion of the expert. There are three experts who provide on each alternative where each alternative are given ten criteria.

Upon the opinions of experts are obtained and then they are processed in means of looking for the criterion aggregation value. Aggregation criteria are used to obtain the criteria aggregation value of each key feature of smart city. There are 6 major smart city features that are used to get negation value. Using the value of the expert judgment matrix, the criterion aggregation is done by the following formula (1).

$$V_{ij} = \text{MIN}\,[\text{Neg}(W_k) \vee V_{ij}(a_k)] \quad (1)$$

Where, MIN is minimum operator, Neg (Wk) is negative value scale, Vij (ak) is the value of the criteria obtained from the assessment expert, k = 1,2,3 ....., n. Then, the negation process are starts from alternatives 1 to 6.

Table 4. Results Negation Alternative 1

Expert	ALT	CRITERIA									
		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Exp. 1	Alt1	F	F	3	0	0	0	0	0	0	0
Exp. 2		F	4	3	0	0	0	0	0	0	0
Exp. 3		F	4	4	0	0	0	0	0	0	0

Then, the formula Vij = MIN [Neg (Wak) / Vij (Ak)] to produce the aggressive value of alternative 1 have been prepared. The results of aggregation criteria alternative 1 including V11(0), V21(0), and V31(0) have been obtained. Hence, the negation and aggregation formula in alternative 1 is also used for 6 alternatives. Meanwhile, the results of negation and aggregation can be seen in Table 5, 6, 7, 8, and 9.

The results of aggregation criteria alternative 2 including V12(5), V22(0), and V32(0) have been achieved. Then, the results of alternative criteria aggregation 3 including V13(5), V23(5), and V33(5). Then, the results of alternative criteria aggregation 4 including V14(0), V24(5), and V34(5). Then, the results of alternative criteria aggregation 5 including V15(5), V25(4), and V35(6). Then, the results of alternative criteria aggregation 6 including V16(6), V26(6), and V36(5).

Table 5. Result Negation Alternative 2

Expert	ALT	CRITERIA									
		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Exp. 1	Alt2	4	4	3	4	4	6	8	2	2	2
Exp. 2		F	F	3	3	4	6	8	F	F	1
Exp. 3		F	F	3	3	4	6	8	2	2	1

Table 6. Result Negation Alternative 3

Expert	ALT	CRITERIA									
		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Exp. 1	Alt3	7	7	4	0	0	0	0	0	0	0
Exp. 2		8	7	4	0	0	0	0	0	0	0
Exp. 3		6	6	4	0	0	0	0	0	0	0

Table 7. Result Negation Alternative 4

Expert	ALT	CRITERIA									
		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Exp. 1	Alt4	6	F	4	0	0	0	0	0	0	0
Exp. 2		6	6	4	0	0	0	0	0	0	0
Exp. 3		3	3	4	0	0	0	0	0	0	0

Table 8. Result Negation Alternative 5

Expert	ALT	CRITERIA									
		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Exp. 1	Alt5	3	3	0	0	0	0	0	0	0	0
Exp. 2		4	4	0	0	0	0	0	0	0	0
Exp. 3		2	1	0	0	0	0	0	0	0	0

Table 9. Result Negation Alternative 6

Expert	ALT	CRITERIA									
		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Exp. 1	Alt6	3	3	0	0	0	0	0	0	0	0
Exp. 2		4	4	0	0	0	0	0	0	0	0
Exp. 3		2	1	0	0	0	0	0	0	0	0

From this process, the aggregation criteria smart city features by importance calculating of each level has been recapitulated. Meanwhile, the recapitulation can be seen in Table 10.

Table 10. Aggregation criteria smart city features outline

Alternatives	Process				Weight Value		
Alt 1	Aggregation criteria result	0	0	0	4	7	10
	Expert aggregation	0					
Alt 2	Aggregation criteria result	5	0	0			
	Expert aggregation	4					
Alt 3	Aggregation criteria result	5	5	5			
	Expert aggregation	5					
Alt 4	Aggregation criteria result	0	5	5			
	Expert aggregation	5					

Alt 5	Aggregation criteria result	5	4	6			
	Expert aggregation	7					
Alt 6	Aggregation criteria result	6	6	5			
	Expert aggregation	8					

Table 10 explained that the final value of the expert aggregation of each alternative is a description of the level of importance set by each expert. From the alternate order 1 is not very important so zero value because the possibility of data that does not much influence on the expert in determining the feature, then alternative 2 has a value of 4 which means it is important, where this criterion becomes important data required by the city to implement smart city features, then alternative 3 which has a mean value of 5 is more important, indicating the city is in need of smart city feature implementation rather than alternative 2. Next, alternative 4 has a weight value of 5 which means more important so that the degree of importance is equal to alternative 3, and alternative 5 has value weight 7 which means absolutely necessary to apply this smart city features in advance compared to alternatives 4 and 3. And last is alternative 6 that has a weight value of 8 which means that the degree of importance is absolutely essential that is the highest degree to be placed is the first feature that should be implemented in this city when enacting smart city-based development.

From the above explanation can be described in Fig. 1 that must be implemented in a city that is categorized as a metropolis because its population is already more than 1 million, here is a simulation picture using multi expert method of multi criteria decision making (ME-MCDM).

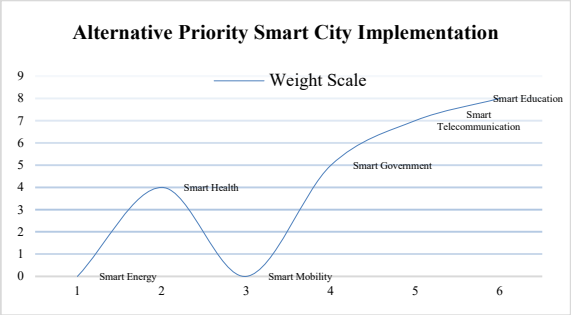

Fig. 2. Graph of Smart City Feature

Displayed on the above graph that there are 6 main features of smart city consisting of smart energy, smart health, smart mobility, smart government, smart telecommunication, and smart education. And the highest order of weight to be implemented first is the smart education with the level of importance of absolutely essential to be applied, then followed by the implementation of smart telecommunication which has the weight of the Essential criterion, and the next application which becomes the third order to be applied is smart government which has more important weight criterion. Then the fourth implementation sequence is smart health which has the weight of the important criterion, and the fifth and sixth implementation has the same criteria weight that is smart energy and smart mobility, as seen in Table 11.

Table 11. Six Smart City Feature Recommendations

ALT	Weight Scale	Level	Criteria
1	0	Null	Smart Energy
2	4	Important	Smart Health
3	0	Null	Smart Mobility
4	5	More Important	Smart Government
5	7	Absolutely Essential	Smart Telecommunication
6	8	Very Absolutely Essential	Smart Education

The recommendation to implement smart city features is substantial because it uses existing data of the city. The criterions are also determined by experts who have surveyed city data by processing and considering the weights used in this study. The result of this sequence can be used by the relevant city to implement the smart city feature in a constructive way so that the development focus can continuously make the city become a smart city and the financing becomes more focused, so that the inter-fields coordination can become more solid.

Smart city-based development with application using smart education feature shows that education problem will affect all areas of life in the city, because the critical point is in human resources. By focusing the development of human resources and then continued development of smart telecommunications either infrastructure development or communication control between the population, will make human resources in the city more open. After the two features become the prominent objectives then smart government development is executed so that the role of the government in the provisions of public service to the city residents can be clearer. Become easier to carry out smart government development as education index has improved and the communication is getting easier, for the next is to improve public healthcare service and simultaneously improve transportation as well as look for alternative energy that can be used for a long-term utilization meant for city residents. That was the flow of smart-city-based development recommended from me-mcdcm process to one of the metropolis cities in Indonesia.

3. Conclusion

Multi-expert multi-criterion decision making (ME-MCDM) model is algorithm using non numeric as principal indicator to process data bolstered by expertise to generate required recommendation that the users need. The principal feature of smart city has a few of parameters that must be modeled so that it can be processed to generate a decision recommendation in the event of initial implementation that

must be carried out by a city that will apply smart city system as a development stepping stone. Smart city framework that has been implemented in developed countries, especially European cities will be difficult if implemented in cities in developing countries like Indonesia because the concept of development from the beginning is different. By using this method me-mcdm focus of development will be more focused so that it can save budget cost, time and also resources needed. Proven this method can be used to solve the problem on the application of smart city features. And the most important thing is to know the smart city features that can be applied or provide input to the lack of parameters according to the city in developing countries.

This research produces recommendations that will be an indicator to measure whether the smart city features adopted from European countries is suitable and applicable in cities in Indonesia or need to be added more main features so that more can be applied maximally and in accordance with the city in developing countries in particular that exist in Indonesia. The succeeding research are to test by way of indicator additions adjusted with the whole city data that have yet to be covered in 6 European frameworks feature in means of creating smart city' additional feature fitting with the cities in the developing nations.

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