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People-Centric Smart City Services Measurement Using Garuda Smart City Framework

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Abstract— **Nowadays, there is a paradigm shift in smart city development from technology-centric to people-centric. The aim is to serve the needs of the community to improve their welfare and quality of life. Smart city service measurement needs to be developed to remain aligned with this paradigm. The areas measured in this people-centric smart city service measurement include three areas: smart city service functionality (related to its fulfillment of human life needs and level of intelligence), quality of life indicators, and citizen perception (on issues related to service clusters). Measurements were carried out in 30 participating cities including 7 large cities, 15 medium cities and 8 small cities. The respondents were the relevant bureaucracy in the local government. The measurement stages include planning, data collection, data processing, data analysis, and lastly interpretation and reporting. The combined results of all measurement areas produce the highest score in the education cluster, then in the industry and small business cluster, and lastly in the urban planning cluster. This research can be used as a good basis for measuring smart city services in other clusters, or even comprehensively at the smart city level. The results of this research contribute insight and ideas for improving smart city services in Indonesia or even the world.**

Keywords—people-centric; smart city; services; measurement; framework

I. INTRODUCTION

In recent years, smart city development commonly use one theme: people-centric, serving the needs of people with the wider aim of improving their well-being and quality of life. People-centric smart city development requires the global governments to see things through the eyes of the public, specifically, to provide the smart city services that meet the needs and preferences of the citizens [1]. A better understanding of citizen perceptions and engagement with smart city initiatives could provide important insights into the public support and valuations regarding their need and appropriateness [2]. Therefore, smart city development must be based on urban development needs. Each stage of smart city development will require different human needs. To better evaluate Smart Cities, Maslow's Hierarchy of Needs Theory which divides human needs into five levels can be adopted [3]. Furthermore, these human needs theory has been used together with the level of service intelligence in people-centric service measurement [4].

Smart city and smart city services development would cause changes or have positive influence on citizen quality of life [5, 6]. The level of quality of life can be measured numerically in various ways by objective indicators, such as using ISO 37120 [7]. This is the first and primary international standard that putting human life quality and improvement in smart city services [8]. This standard contains a set of indicators that provide a uniform approach to what is measured, and how the measurement is carried out [9].

There is a growing amount of research being done on people-centric smart city services, but no one has addressed or even measured them across various aspects of people-centric paradigm at once. Therefore to address this knowledge gap, we aim to present the smart city services measurement in Indonesia using the people-centric approach, that measure three aspects: the ability of smart city services to meet human needs, citizen perceptions, and quality of life. This smart city service measurement adopts the Garuda Smart City Framework [10, 11], with some adjustments to our people-centric paradigm.

II. METHODOLOGY

Conceptual Framework

To measure the smart city services in people-centric paradigm, we adopted a conceptual framework combined

from research model developed by He, et al. [6], Quality of Life indicators in ISO 37120:2018 [9], Maslow's hierarchy of needs, and level of intelligence of smart products [12] as in Figure 1.

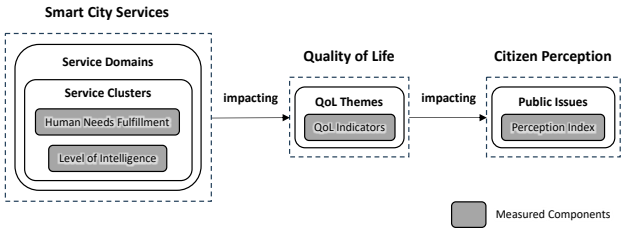

Figure 1. Conceptual Framework of People-Centric Smart City Services Measurement

Smart city services will be impacting the quality of life, and the quality of life will be impacting the citizens perception. Smart city services are divided into three service domains (economy, society, and environment). Each domain consists of some service clusters, and cluster will be measured by considering its ability to meet human needs, along with its level of intelligence. Quality of Life are classified into several themes, and each theme has its own indicators. Citizen perception will be different for each public issue, and each issue has a different perception index.

The scope of this measurement is 30 cities in Indonesia, including 7 large cities, 15 medium cities and 8 small cities. The object of measurement is the service provided by the local government in each service cluster. The respondents are the relevant bureaucracy in local governments. This measurement is part of the Indonesian Smart City Ranking organized by the Smart City and Community Innovation Center (SCCIC) which was carried out in 2023. The structure of participating cities is as in Table 1.

TABLE I. STRUCTURE OF PARTICIPATING CITIES

Category	Participating Cities	Subtotal
Large City	Bandung, Batam, Bogor, Depok, Semarang, Surabaya, Tangerang	7
Medium	Ambon, Cimahi, Denpasar, Jambi, Kediri, Madiun, Malang, Pekalongan, Pontianak, Probolinggo, Solok, Surakarta, Tarakan, Tasikmalaya, Tegal	15
Small	Bukittinggi, Magelang, Mojokerto, Padang Panjang, Parepare, Pariaman, Pematang Siantar, Sawah Lunto	8
Total		**30**

Measurement Stages

Measurements are carried out in several stages:

- Planning, including determining survey objectives, obtaining respondent information, and designing questionnaires.
- Data collection, by distributing questionnaires to predetermined respondents.
- Data processing, including conversion of raw data into appropriate output forms, and verification of evidence.
- Data analysis, by calculating maturity levels.
- Interpretation and reporting, including interpretation and presentation of data analysis results in report form.

This study measures the three area of people-centric smart city services below, as in Figure 1, with their respective indicators and measurement scales.

A. Smart City Services

Table II shows some indicators related to human needs fulfillment for selected service clusters in each service domain. Each service cluster can satisfy one or more categories of human needs. Each category of human needs is represented by one indicator to check whether it exists or does not exist, and the definition of each category is adopted based on Desmet and Fokkinga [13], and explained in Table III. Some of the indicators are adopted, simplified and developed based on Santosa, et al. [14]

TABLE II. HUMAN NEEDS FULFILLMENT INDICATORS

Service Domains/ Service Clusters	Category of Human Needs	Indicators (Exist/Not Exist)
Economy/ Smart Industry & Small Business	1. Physiological	Industrial and SME product catalog
	3. Social	Media sharing and promotion of industrial and SME products
	5. Self-Actualization	Industrial and SME product transaction portal
Society/ Smart Education	1. Physiological	Education unit catalogue
	2. Safety	System for monitoring and reporting problems in educational areas (such as bullying and sexual violence)
	3. Social	Integrated online communication and consultation media between parents, teachers and students
	4. Esteem	Student attendance and learning progress tracking system (online report card)
	5. Self-Actualization	Online learning system
Environment/ Smart Urban Planning	1. Physiological	Geospatial map of city layout
	2. Safety	Monitoring and reporting system for problems related to urban spatial planning
	3. Social	Public communication media related to city spatial planning
	5. Self-Actualization	Online building permit services

TABLE III. CATEGORIES OF HUMAN NEEDS

Category	Description
1. Physiological	The basic needs of any living organism: the requirements for the body to survive
2. Safety	Security, stability, predictability, protection, freedom from fear
3. Social	The need for belonging, love, intimacy, and affection
4. Esteem	The needs for validation from others (status, respect, recognition, reputation), and positive self-evaluation (competence, confidence in ability, accomplishment, skills mastery)
5. Self-Actualization	The need for self-fulfillment, growth, creativity, morality, and meaning making

Table IV shows level of intelligence for each service clusters in three solution categories: non-technological, digitization [15] and automation [12]. Each service cluster represents a different development stage with its own

description. The lowest stage is no innovation, and the highest stage is acting.

TABLE IV. LEVEL OF INTELLIGENCE FOR SMART SERVICES

Solution Category	Level of Intelligence	Development Stages	Description
Non-Technological	None	No Innovation	Service provided without business and technology innovation
	Business Model Innovation	Innovating	The service has adopted an innovative business model, without involving new technologies
Digitization	Digital Conversion	Digitizing	Services can be accessed in digital form
Automation	Information Handling	Sensing	Smart services can manage given and collected information by itself
	Problem Notification	Understanding	Smart services can process the information, and send relevant notifications by itself
	Decision Making	Acting	Smart services can make relevant decisions by itself

Each indicator of human needs fulfillment will be checked for its existence, the validity of the evidence, and the level of intelligence as in Table V. The lowest level represents conditions where services do not meet human needs, and the highest level represents conditions where services meet human needs with valid evidence and their intelligence has reached the decision-making level.

TABLE V. SMART CITY SERVICES MEASUREMENT SCALES

Level	Needs Fulfillment	Evidence	Level of Intelligence
Level 0	Not Exist	-	-
Level 1	Exist	Not Available/ Not Valid	-
Level 2	Exist	Valid	None
Level 3	Exist	Valid	Business Model Innovation, Digital Conversion, or Information Handling
Level 4	Exist	Valid	Problem Notification
Level 5	Exist	Valid	Decision Making

B. *Quality of Life*

Table VI show quality of life indicators for selected service clusters. Each service cluster is represented by only one indicator. Each quality-of-life indicator will be measured by using measurement scales in Table VII.

TABLE VI. QUALITY OF LIFE INDICATORS

Service Domains/ Service Clusters	Indicators
Economy/ Smart Industry & Small Business	City's unemployment rate
Society/ Smart Education	Percentage of school-aged population enrolled in schools
Environment/ Smart Urban Planning	Number of trees per 100.000 population

In Table VII, the lowest level represents conditions where there is no data, and the highest level is the highest value of each indicator.

TABLE VII. SMART CITY SERVICES MEASUREMENT SCALES

Level	Indicators		
	City's unemployment rate (%)	***School-aged population enrolled in schools (%)***	***Number of trees per 100.000 population***
Level 0	No data	No data	No data
Level 1	>12%	<60%	≥0 – <10.000
Level 2	≥9% – <12%	≥60% – <70%	≥10.000 – <20.000
Level 3	≥6% – <9%	≥70% – <80%	≥20.000 – <40.000
Level 4	≥3% – <6%	≥80% – <90%	≥40.000 – <80.000
Level 5	≥0% – <3%	≥90% – <100%	≥80.000

C. *Citizen Perception*

Table VIII show some indicators related to the perception of public issues for selected service clusters.

TABLE VIII. PUBLIC ISSUES

Service Domains/ Service Clusters	Public Issues
Economy/ Smart Industry & Small Business	Unemployment issues
Society/ Smart Education	Educational issues
Environment/ Smart Urban Planning	Spatial planning issues

Each public issue has 3 possible perceptions: positive, negative, and neutral. Each has different points and will determine the calculation of Citizen Perception Index (CP_{Index}) as in (1) below. Positive opinion points are worth 2, negative opinions are worth -2, and neutral opinions are worth 1.

$$CP_{Index} = \frac{(2 \times Pos) - (2 \times Neg) + (1 \times Neu)}{(Pos + Neg + Neu) \times 2} \times 100\% \quad (1)$$

Where *Pos* is the number of positive opinions, *Neg* is the number of negative opinions, and *Neu* is the number of neutral opinions. Opinions were collected from news articles and social media for almost a year, using media analytics services from an Indonesian company ranked among the five best in the world.

D. *People-Centric Smart City Services*

The final score for people-centric smart city services is based on the sum of the three measurement areas, with assessment weights for each area as in Table IX. This calculation weight applies to all service clusters and all city categories.

TABLE IX. OVERALL ASSESSMENT WEIGHT OF EACH MEASUREMENT AREA

Measurement Area	Weight
Smart City Services	40%
Quality of Life	30%
Citizen Perception	30%
Total	100%

III. RESULTS AND DISCUSSIONS

Based on measurements carried out in several cities in Indonesia, the results are described in each area, and finally as a whole as follows.

A. Smart City Services Area Measurement

From Table X we can see that the average smart city service in selected clusters in Indonesia is still at level 2. This means that the service has met human needs, with valid evidence, even though it still lacks intelligence or innovation in both business processes and technology.

TABLE X. AVERAGE VALUE AND LEVEL OF SMART CITY SERVICES IN EACH SERVICE CLUSTER

City Category	Service Cluster		
	Smart Industry & Small Business	***Smart Education***	***Smart Urban Planning***
Large	2,19 (Level 2)	1,85 (Level 2)	2,14 (Level 2)
Medium	2,44 (Level 2)	1,65 (Level 2)	1,92 (Level 2)
Small	0,50 (Level 1)	0,98 (Level 1)	1,31 (Level 1)
Average	1,71 (Level 2)	1,49 (Level 1)	1,79 (Level 2)

If we look at the average value in Table X, it is found that the best local government services are in the urban planning services, followed by smart industry & small business services, and the lowest in education services.

Figure 2-5 visualizes the average level of smart city services in selected clusters. In general, large cities and medium cities have slightly different levels, but are still higher than small cities. The highest and lowest average scores for smart city services in fulfilling human needs are in the industry & small business cluster, where the highest score is at level 3 in large and medium cities, while the lowest is at level 0 in small cities.

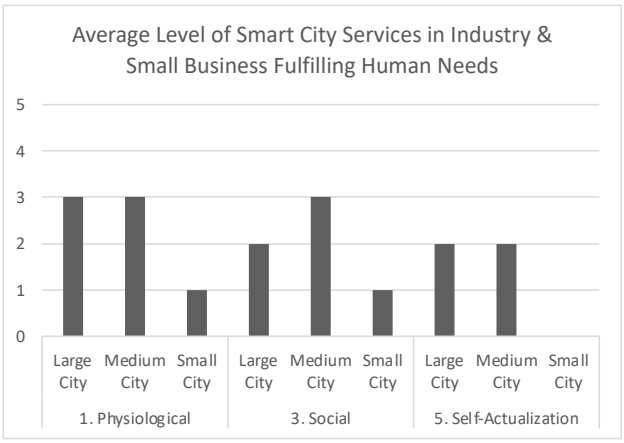

Figure 2. Level of Smart City Services In Industry & Small Business

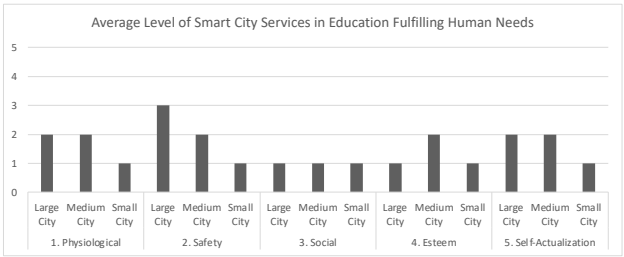

Figure 3. Level of Smart City Services In Smart Education

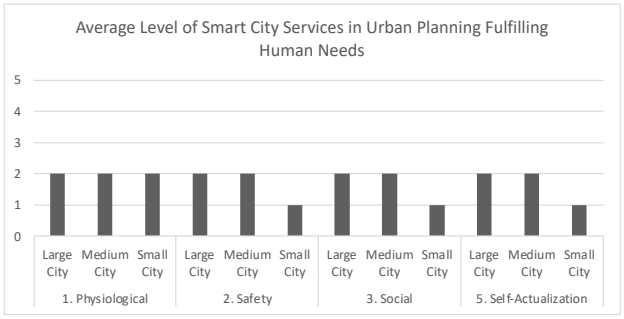

Figure 4. Level of Smart City Services In Smart Urban Planning

B. Quality of Life Area Measurement

Based on Table XI, the smallest level of smart city services is in the urban planning cluster, with indicators related to the number of trees where the average value ranges between levels 0-1. This is due to limited data provided by local governments, which is only provided by 4 large cities, 7 medium cities and 2 small cities.

In other clusters, data is provided in full by all local governments. We can see that the highest level of quality of life is found in the education cluster, where each city category on average reaches level 4. This means that 80-90% of the school age population has enrolled in school. The interesting is that in the industry 7 small business cluster, cities in the small category have the lowest unemployment rate, namely at level 4, with an unemployment rate of 3-6%. Meanwhile, in large and medium cities, the unemployment rate is at level 3, which is around 6-9%.

TABLE XI. QUALITY OF LIFE AVERAGE LEVEL IN EACH INDICATOR

City Category	Indicators		
	City's unemployment rate (%)	***School-aged population enrolled in schools (%)***	***Number of trees per 100.000 population***
Large	Level 3	Level 4	Level 1
Medium	Level 3	Level 4	Level 1
Small	Level 4	Level 4	Level 0

C. Citizen Perception Area Measurement

From Table XII we can see that in the industry & small business and education clusters, the larger the city category, the lower citizens' perceptions of smart city services in that cluster. This could be because the needs and expectations of services in these clusters are higher in larger cities. On the other hand, in urban planning clusters, the larger the city category, the higher the public's perception of smart city services. This could be due to better urban planning in larger cities.

TABLE XII. CIZITEN PERCEPTION INDEX IN EACH SERVICE CLUSTER

City Category	Service Cluster		
	Industry & Small Business	***Education***	***Urban Planning***
Large	46%	69%	43%
Medium	55%	72%	27%
Small	66%	79%	37%
Average	55%	73%	36%

D. *People-Centric Smart City Services Measurement (All Area Combined)*

Based on calculations in all areas as in Table XIII, it was found that in general the services provided by the local government were better in education cluster, then the industry & small business cluster, and the last is in urban planning cluster.

TABLE XIII. PEOPLE-CENTRIC SMART CITY SERVICES LEVEL IN EACH SERVICE CLUSTER

City Category	Service Cluster		
	Industry & Small Business	***Education***	***Urban Planning***
Large	2,47 (Level 2)	2,97 (Level 3)	1,80 (Level 2)
Medium	2,70 (Level 3)	2,94 (Level 3)	1,47 (Level 1)
Small	2,38 (Level 2)	2,78 (Level 3)	1,07 (Level 1)
Average	2,52 (Level 3)	2,90 (Level 3)	1,45 (Level 1)

IV. CONCLUSIONS

Each area of the people-centric smart city services measurement results in a different level of maturity. In the smart city service area, the highest average score was obtained in the urban planning cluster, while in the quality of life area the highest average score was obtained in the education cluster, and in the citizen's perception area the highest average score was obtained in the education cluster. The combined results from all areas produce the highest score in the education cluster, then the business cluster, and the last in the urban planning cluster.

In this research, limited data related to quality of life indicators was one of the obstacles. In subsequent measurements, it is important to carry out two-way communication and coordination with relevant bureaucracy so that there is no confusion in filling in indicators according to the specified units, as well as having the same views in measurement.

This research can be used as a basis for measuring smart city services in other clusters. Apart from that, it can be further developed for a more comprehensive measurement of smart city services, from input to impact.

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