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A Regulation-Based Readiness Assessment Model for Smart City Development in Indonesia

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Purpose: This study addresses the lack of a smart city readiness assessment instrument that is explicitly aligned with Indonesia's urban governance framework, particularly Government Regulation No. 59 of 2022. Existing readiness models often provide generic or technology-centred measures and do not sufficiently operationalise national regulatory requirements, limiting their utility for Indonesian local governments. To fill this gap, the study develops a regulation-based smart city readiness model comprising measurable, context-specific indicators that support readiness evaluation prior to implementation. The research adopts a Design Science Research (DSR) methodology, supported by a PRISMA-guided Systematic Literature Review to identify and synthesise candidate indicators, followed by iterative refinement. Instrument validation was conducted through expert judgement, face validity, and inter-rater reliability testing using Cohen's Kappa. The final output is a validated readiness assessment instrument consisting of 70 indicators organised into five regulation-derived dimensions: infrastructure, facilities, public utilities, human resources, and suprastructure. Reliability results show strong inter-rater agreement (κ = 0.895), indicating robust and consistent indicator classification. The study contributes a policy-aligned readiness instrument grounded in Indonesia's regulatory context and provides local governments with a standardised tool to assess readiness, identify development gaps, and support evidence-based planning for sustainable smart city implementation.

Keywords: Smart city; Readiness; Regulation; Indicators; Indonesia

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1. INTRODUCTION

Cities worldwide are increasingly facing complex challenges related to urbanization, environmental pressure, and socio-economic inequality [1]. In response, the smart city concept has emerged as an approach that integrates information and communication technology (ICT) into urban governance to improve efficiency, service quality, and decision-making[2], [3], [4]. However, beyond technological adoption, successful smart city implementation requires adequate readiness across multiple dimensions, including infrastructure, institutions, and human resources [5], [6].

While smart city initiatives have become a global trend aimed at enhancing public services, governance efficiency, and citizen participation [7], many regions still face readiness challenges. In Indonesia, disparities in digital and institutional preparedness persist, prompting the government to launch the "Gerakan Menuju 100 Smart City" program to support local governments in smart city planning. Nevertheless, effective implementation requires systematic readiness evaluation that extends beyond technology to include infrastructure, governance structures, and human resources.

Prior studies report varying levels of smart city readiness across Indonesian cities. For instance, Yogyakarta has fulfilled more than half of the readiness indicators, although limitations in human resource capacity remain Other studies apply frameworks such as the Technology–Organization–Environment (TOE) model to emphasize the balance between technological, organizational, and environmental factors [8] , while case studies in cities such as Surakarta highlight challenges related to data availability and quality [9]. Although these studies provide valuable insights, they are largely case-specific and do not offer a standardized readiness assessment aligned with Indonesia's national regulatory framework.

Although existing studies provide important insights into smart city readiness, they do not explicitly incorporate Indonesia's latest regulatory framework, namely Government Regulation No. 59 of 2022 on Urban Affairs [10], This regulation formally defines key urban components including infrastructure, facilities, public utilities, and governance structures that should underpin smart city development. To date, no readiness model has operationalized these regulatory definitions into measurable indicators, resulting in the

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absence of a standardized, policy-aligned instrument for assessing smart city readiness across Indonesian regions.

Previous research has predominantly focused on technological readiness, organizational capability, or case-specific assessments. While these approaches provide valuable insights, few studies have addressed the need for a nationally contextualized readiness model grounded in Indonesia's urban governance regulations. In particular, limited attention has been given to operationalizing Government Regulation No. 59/2022 into measurable readiness indicators. This gap poses challenges for local governments in evaluating readiness in alignment with national policy, potentially resulting in implementation failures related to technology, governance, or sustainability [11]. Therefore, this study aims to develop a regulation-based smart city readiness model tailored to Indonesia's governance context. Specifically, the objectives of this research are:

1. To identify and construct readiness indicators aligned with Governement Regulation No. 59/2022, and
2. To develop a reliable measurement instrument for assessing regional readiness across key dimensions of smart city implementation.

This study contributes to the literature by advancing theoretical understanding of smart city readiness within a regulatory context and by providing a practical, policy-aligned assessment tool for Indonesian local governments.

2. METHODS

2.1. Design Science Research approach

This study employed Design Science Research (DSR) as the overarching methodology to develop and validate a smart city readiness assessment model aligned with Government Regulation No. 59/2022. DSR is appropriate because it provides a structured process for designing, developing, and evaluating artefacts that address practical, real-world problems while maintaining methodological rigor [12]. In this study, DSR guided the end-to-end workflow: (i) articulating the regulatory and practical gap, (ii) defining design objectives, (iii) developing readiness dimensions and indicators from the literature, and (iv) validating the resulting measurement instrument through expert review and reliability testing. The mapping between DSR stages and the corresponding research activities is summarised in Table 1.

Table 1. Mapping of DSR stages to research activities and outputs

DSR stage	Research activities	Output
Problem identification	Identified the absence of a regulation-based smart city readiness instrument aligned with Government Regulation No. 59/2022	Research problem and question
Objective definition	Defined objectives for developing a regulation-aligned readiness model and measurement instrument	Research objectives
Design and development	PRISMA-guided systematic literature review (SLR); indicator extraction; thematic coding and consolidation	Preliminary readiness dimensions and indicators
Demonstration	Expert judgement and face validity review	Refined indicator set and instrument wording
Evaluation	Inter-rater reliability testing using Cohen's Kappa	Validated readiness instrument
Communication	Documentation of model, indicators, and instrument	Final readiness model and measurement tool

2.2. Systematic Literature Review and indicator extraction

To establish a defensible theoretical foundation for the readiness model and to compile candidate indicators, a Systematic Literature Review (SLR) was conducted using the PRISMA protocol [13]. The SLR focused on identifying published smart city readiness frameworks that include measurable and operational indicators, consistent with the study's emphasis on an assessment instrument rather than a purely conceptual model. The search was performed in Scopus, IEEE Xplore, and Google Scholar using predefined keywords and screening rules. Table 2 summarises the search sources and criteria to enhance transparency and replicability.

Table 2. SLR search sources and screening criteria

Component	Description
Databases	Scopus; IEEE Xplore; Google Scholar
Keywords	"smart city readiness"; "smart city readiness model"; "readiness indicators"; "urban digital readiness"
Inclusion criteria	Studies proposing or evaluating smart city readiness frameworks with measurable indicators (multi-domain readiness, not technology-only)
Exclusion criteria	Studies focused solely on technological/ICT infrastructure readiness without broader governance, policy, service, or institutional indicators
Final studies included	30 peer-reviewed articles

2.3. PRISMA screening outcome

The database search yielded 1,050 records. Duplicates were removed, and titles/abstracts were screened against the inclusion and exclusion criteria. Full texts were then assessed for eligibility, resulting in 30 studies retained for qualitative synthesis (PRISMA flow illustrated in Figure 2). The reduction reflects the study's requirement for frameworks that explicitly present readiness indicators applicable across multiple domains, beyond technology alone. The retained studies were synthesised to inform the conceptual structure of the readiness model. The final theoretical foundation was constructed by adopting and adapting key elements from established readiness frameworks, including:

1. ASCIMER Readiness Model [14]
2. Technology–Organization–Environment (TOE) Readiness Framework [8]
3. IES-City Framework [15]
4. Smart City Council Readiness Framework [16], [9]
5. Iranian Smart City Readiness Measurement Framework [17]
6. Smart City Mission (SCM) India Readiness Model [18]
7. China Smart City Readiness Model [19]
8. Indonesia's "Gerakan Menuju 100 Smart City" Masterplan Development Guide [7]

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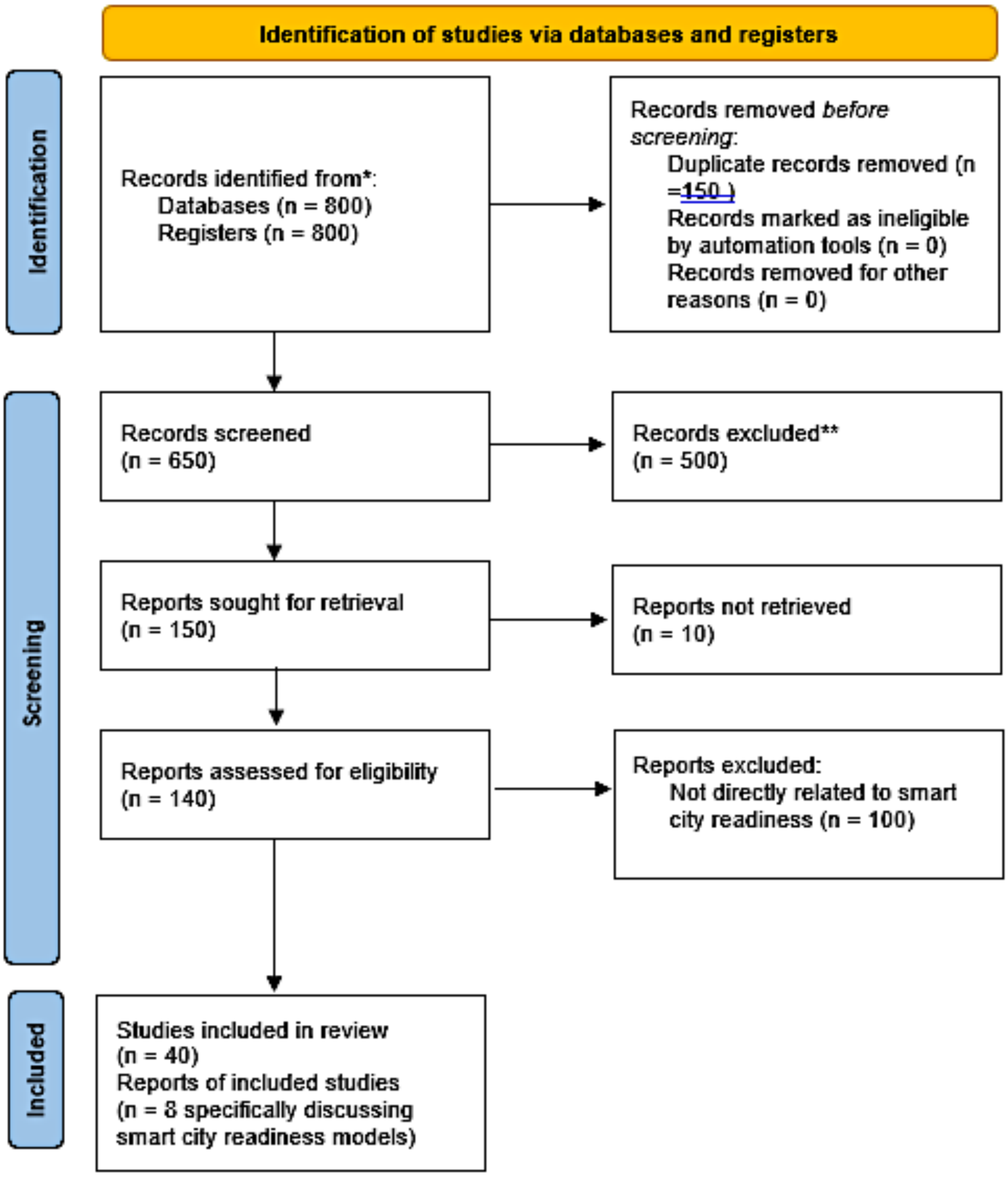

Figure 2. PRISMA Flow Diagram

2.4. Instrument development

Candidate indicators were extracted from the included studies and compiled into a preliminary indicator pool. Indicators were then coded and consolidated thematically to remove redundancy, harmonise terminology, and ensure alignment with the regulatory intent of Government Regulation No. 59/2022. Where necessary, indicators were reworded to be (i) measurable, (ii) context-appropriate for public-sector assessment, and (iii) interpretable by intended users of the instrument [20], [21].

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2.5. Validation and reliability assessment

The developed measurement instrument was subjected to validity and reliability procedures to ensure that it measures smart city readiness consistently and appropriately.

1) Content validity (expert judgement)

Content validity assesses whether indicators are relevant, comprehensive, and appropriate for the construct being measured [22]. Consistent with recommended qualitative approaches [21], content validity was evaluated through expert judgement by two domain experts with experience in smart city governance and policy implementation. The expert selection criteria included: (i) demonstrated knowledge of smart city implementation in Indonesia and/or (ii) professional responsibilities in government agencies related to smart city policy, planning, or implementation. Experts reviewed each indicator and its placement within the proposed dimensions, recorded agreement (e.g., retain/revise/remove), and provided qualitative feedback on relevance, clarity, and regulatory alignment. Recommendations were incorporated to refine indicator definitions and remove ambiguity.

2) Face validity (clarity and usability)

Face validity was used to assess whether the instrument appears understandable, readable, and professionally presented from the perspective of intended respondents [21]. A small group of reviewers assessed each item for clarity, wording, and interpretability, and provided comments on problematic phrasing, confusing terminology, and overall usability. Edits were applied to improve readability and reduce misinterpretation without altering the intended construct meaning.

3) Inter-rater reliability (Cohen's Kappa)

To evaluate the consistency of expert ratings and reduce the likelihood of subjective bias, the study applied inter-rater reliability testing. Specifically, agreement between expert assessments was quantified using Cohen's Kappa, which measures rater agreement beyond chance and is commonly used for categorical judgements (e.g., retain vs revise vs remove) [23]. Indicators demonstrating weak agreement were revisited, refined, and—where necessary—reassessed to strengthen instrument stability.

2.6. Refinement and final output

Following expert validation and reliability testing, the instrument was revised and finalised. The end product of the study is a regulation-aligned smart city readiness model, consisting of readiness dimensions with mapped indicators and a complete measurement instrument suitable for readiness assessment in the context of Government Regulation No. 59/2022. Future work may strengthen generalisability by engaging a larger and more diverse expert panel and applying the instrument across multiple municipalities to evaluate performance across varied implementation contexts.

3. RESULTS AND DISCUSSION

3.1. Extraction Process and Conceptual Model Development

The systematic extraction and synthesis process produced a comprehensive pool of 353 smart city readiness indicators drawn from the eight selected smart city readiness frameworks (Figure 3). These indicators represented diverse readiness perspectives across governance, service delivery, infrastructure, institutional capacity, and enabling technologies. To ensure the resulting instrument remained regulation-aligned and suitable for a national policy environment, the indicators were categorised using a deductive, theory-driven thematic analysis grounded in the conceptual structure of Government Regulation (PP) No. 59 of 2022. This deductive approach was selected deliberately because it supports classification against predefined constructs, strengthening conceptual coherence and improving measurement validity by reducing the risk of misalignment between extracted indicators and the regulation-based dimensions [24].

3.1.1. Multi-stage coding and indicator consolidation

Consistent with a structured synthesis approach, the indicator refinement followed three stages [25]. First, open coding was applied to the full set of indicators to identify conceptual similarity across frameworks. Indicators with comparable definitions, operational intent, or measurement focus were grouped into preliminary clusters (e.g., transport readiness, ICT enablement, institutional coordination). Second, axial coding was used to examine relationships between clusters and consolidate overlapping indicators, particularly those that differed only in phrasing but reflected the same readiness function. This stage was essential for removing duplication and ensuring each indicator maintained a distinct conceptual boundary. Third, selective coding was used to map the synthesised indicators into the five readiness dimensions explicitly derived from Government Regulation No. 59/2022, namely: infrastructure, facilities, public utilities, human resources, and suprastructure [25]. This final mapping ensured that the emerging readiness instrument was structurally consistent with national governance definitions rather than being driven solely by international framework logic.

The consolidation mechanism is illustrated by the transport-related case example. During open coding, indicators such as "road availability," "road condition," and "road accessibility" repeatedly appeared across frameworks under transport or mobility readiness. These indicators were conceptually related and operationally inseparable, because they measure different aspects of the same core readiness requirement. Through axial coding, they were merged into a single indicator capturing "availability and condition of road infrastructure." This consolidation reduced redundancy while preserving the meaning required to assess readiness within the infrastructure definition of Government Regulation No. 59/2022.

3.1.2. Regulation-aligned readiness dimensions

As shown in Figure 3, the final conceptual model positions the five dimensions as the central structure through which readiness is evaluated. Each dimension is supported by evidence from the reviewed frameworks and aligns directly with the regulation's governance logic.

1) Infrastructure Dimension

The infrastructure dimension reflects the readiness of foundational urban assets that enable core city functioning and support integration of advanced systems. The literature consistently identifies infrastructure readiness as a prerequisite for smart city development, because smart city functions cannot scale effectively without reliable physical foundations [26], [27]. This aligns with Government Regulation No. 59/2022, where infrastructure includes fundamental elements supporting urban life, for example road access availability across the city.

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2) Facilities Dimension

Facilities refer to enabling infrastructure that supports daily activities and access to essential services. The importance of linking facilities with broader infrastructure readiness is highlighted in prior work, which indicates that smart city progress depends not only on core systems but also on service-supporting facilities that operationalise those systems for citizens [26]. This is consistent with Government Regulation No. 59/2022, which defines facilities as infrastructure supporting daily activities, such as educational services.

3) Public Utility Dimension

Public utilities capture readiness for essential environmental and basic services (e.g., water, energy, sanitation, waste systems) that must function reliably to support urban sustainability and smart operations. Research emphasises that managing water, energy, and waste is central to achieving the smart city vision [28]. In Government Regulation No. 59/2022, public utilities are framed as supporting elements providing basic environmental services, with the availability of data centres being an example of enabling capacity relevant to integrated service delivery.

4) Human Resources Dimension

Human resources readiness captures workforce competence, organisational capability, and development capacity needed to implement and sustain smart city initiatives. The reviewed evidence supports the view that technology readiness must be accompanied by human development readiness to achieve sustainable, long-term smart city progress [29]. This dimension therefore reflects the regulation-based requirement that the people and skills layer must be prepared to plan, operate, and adapt smart city systems.

5) Suprastructure Dimension

The suprastructure dimension represents institutional, regulatory, and governance arrangements that establish legitimacy, coordination, and accountability for smart city implementation. Research underscores that regulatory readiness is critical to ensuring technological advancement remains aligned with societal needs and governance priorities [30]. This supports the positioning of suprastructure as a decisive readiness domain, because technology implementation without policy and institutional readiness often produces fragmented or unsustainable outcomes.

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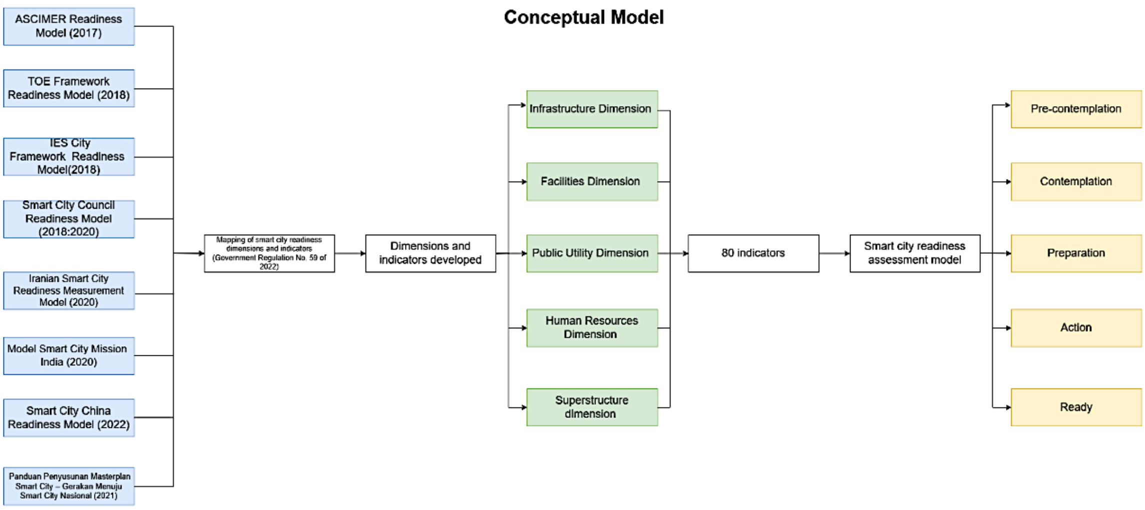

Figure 3. Conceptual Model

3.1.3. Output of the extraction process

Through iterative refinement and regulation-based mapping, the initial pool of 353 indicators was reduced to a final set of 80 indicators. The reduction was not merely a numerical compression; rather, it reflects the elimination of duplication, resolution of semantic overlap, and strengthening of conceptual clarity to ensure each indicator could function as a practical measurement item. The final indicator distribution across the regulation-aligned dimensions (Figure 3) is as follows:

1) Infrastructure: 19 indicators
2) Facilities: 8 indicators
3) Public utilities: 17 indicators
4) Human resources: 17 indicators
5) Suprastructure: 19 indicators

This distribution demonstrates a balanced instrument structure, with strong representation across both "hard" readiness requirements (infrastructure, public utilities) and "soft" governance and capability requirements (human resources, suprastructure). Importantly, Figure 3 further shows that the final 80 indicators constitute the operational core of the smart city readiness assessment model, which classifies readiness into five staged levels: pre-contemplation, contemplation, preparation, action, and ready. This staging adds practical value by enabling readiness interpretation in progressive terms (i.e., from low readiness to full readiness), rather than producing only static indicator scores. Figure 3. Conceptual Model therefore summarises the full results pathway:

indicators are sourced from the eight frameworks, mapped to Government Regulation No. 59/2022, consolidated into five dimensions, refined into 80 validated indicators, and structured into an assessment model that supports staged readiness outcomes.

3.2. Expert Judgements

Expert judgement was conducted to assess the relevance, clarity, and contextual suitability of the 80 preliminary readiness indicators derived from the extraction and synthesis stage. Two experts were purposively selected because they met the study's eligibility criteria, including substantial experience within government institutions and direct involvement in smart city formulation and implementation. Their practical exposure ensured that the review was grounded in the realities of Indonesian public-sector governance, regulatory obligations, and data availability.

Each expert independently evaluated every indicator using a binary relevance assessment (relevant = "Yes", not relevant = "No") and provided qualitative comments to justify their decisions and recommend refinements. In addition to relevance, experts were invited to comment on: (i) whether the indicator could be operationalised at the district/city level, (ii) whether the indicator was consistent with the intent and scope of Government Regulation No. 59/2022, and (iii) whether data to support measurement would be realistically obtainable through government information systems. This combination of structured rating and open feedback ensured that the indicator set was not only theoretically meaningful but also implementable in practice.

3.3. Content Validity

Content validity was established through expert review to ensure that the proposed dimensions and indicators adequately represent the construct of smart city readiness and are appropriate for use prior to implementation. This validation focused on two aspects: (1) the suitability of the five regulation-aligned dimensions, and (2) the relevance and feasibility of the 80 readiness indicators included in the draft instrument.

The validation process was administered using an expert assessment sheet, enabling reviewers to (i) rate each indicator's relevance and (ii) provide written explanations and suggestions for revision or removal. Overall, the experts confirmed that the instrument structure was appropriate and that the majority of indicators were aligned with readiness

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measurement needs. However, 10 indicators were judged as not suitable for inclusion in the Indonesian district/city readiness instrument. The reasons provided for exclusion clustered into two dominant themes:

1) Regulatory non-essentiality: the indicator represents a desirable feature but is not an obligation or readiness requirement at the district/city level under the regulatory context.
2) Practical measurability constraints: the indicator is conceptually meaningful but cannot be reliably measured because required data are unavailable, not recorded by responsible agencies, or not maintained in a way that supports systematic assessment.

The excluded indicators and expert justifications are presented in Table 1.

Table 1. Explanation of Irrelevant Indicators

No.	Indicator	Explanation
	Infrastructure Dimension	
16	Availability of air sensors	There is no obligation for each district/city to have air sensor equipment, so this indicator is not needed.
19	The amount of public wireless locations	No data is available regarding the number of public wireless locations in the district/city.
	Facilities Dimension	
20	The presence of Public Open Space at the community unit level	The community unit does not have a specific place for activities, so this indicator is not necessary.
24	The presence of community learning activity centers at the village/sub-district level	Community learning activity centers are not yet available at the village/sub-district level, so there is no data to meet this indicator.
	Public Utility Dimension	
39	Number of power outages per month (in hours)	No data related to the number of power outages is recorded at the Department of

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No.	Indicator	Explanation
		Communication and Information. Therefore, this indicator is not relevant.
	Human Resources Dimension	
48	The program involves online citizen participation	The training program only involves OPD employes. Citizens are not involved but are only informed (through social media or if they come in person). This indicator is not necessary.
50	Number of interest/talent/hobby/creative communities in the area.	The number of communities is likely very high. The district/city does not have concrete data.
51	The presence of a community of ICT software developers in the area	District/city do not have clear data regarding local ICT developer communities.
	Supastructure Dimension	
74	The existence of community self-help forums supporting smart cities	District/city do not have clear data regarding community self-help forums supporting smart cities
75	The number of community self-help forums supporting smart cities	District/city do not have clear data regarding community self-help forums supporting smart cities.

Source: Researcher's findings

Following the removal of these 10 indicators, the remaining items were deemed suitable for inclusion in the measurement instrument. The expert review therefore strengthened the instrument by improving (i) content relevance, (ii) regulatory and contextual fit, and (iii) data feasibility for district/city-level readiness assessment in Indonesia.

3.4. Face Validity

Face validity was undertaken to confirm that the measurement instrument is clear, readable, and practically usable by its intended users—local government officials responsible for planning and implementing smart city initiatives. The review focused on whether each indicator was presented in language that is easy to interpret, free from technical jargon, and unambiguous in meaning, so that respondents could provide consistent responses without requiring additional explanation. Overall, feedback indicated that the indicators were well-formulated and understandable, and that the structure and wording of the instrument supported straightforward completion. No indicator was flagged as confusing or misleading, and none required substantive revision. Where minor comments were provided, they related mainly to improving phrasing consistency and ensuring uniform terminology across dimensions rather than altering indicator intent. This face validity step strengthens the instrument's administrative feasibility, indicating that it can be deployed across regional government units in a consistent manner and interpreted reliably without specialised technical training. In combination with expert-based content validation, the face validity results support the instrument's suitability for routine readiness assessment in local government contexts.

3.5. Reliability Measurement Using Cohen's Kappa

Inter-rater reliability assesses the extent to which independent raters provide consistent judgements when evaluating the same items. In this study, reliability was assessed using the kappa coefficient, which quantifies agreement by comparing the observed agreement (Po) against the agreement expected by chance (Pe) [31]. When there are two raters, this statistic is specifically referred to as Cohen's Kappa [23]. Cohen's Kappa is particularly appropriate here because the expert evaluation used a binary classification ("Yes" = accept/relevant; "No" = reject/irrelevant), and simple percentage agreement alone can overestimate reliability by ignoring chance agreement.

Cohen's Kappa was calculated based on the expert judgement outcomes from the content validity assessment. Of the 80 indicators, both experts agreed to accept 68 indicators ("Yes–Yes") and agreed to reject 10 indicators ("No–No"). Only two indicators resulted in disagreement: one case where Rater 1 = Yes and Rater 2 = No, and one case where Rater 1 = No and Rater 2 = Yes. This yields the following agreement structure:

1) Total agreements = 68 + 10 = 78
2) Total disagreements = 2
3) Observed agreement (Po) = 78/80 = 0.975

Cohen's Kappa was computed using Equation 1.

$$\kappa = \frac{Po - Pe}{1 - Pe} \quad (1)$$

where P_o is the observed proportion of agreement and P_e is the proportion of agreement expected by chance [23]. To compute P_e, the marginal totals were first derived from the rating outcomes:

1) Rater 1: Yes = 69, No = 11
2) Rater 2: Yes = 69, No = 11

Thus,

$$P_e = \left(\frac{69}{80} \times \frac{69}{80}\right) + \left(\frac{11}{80} \times \frac{11}{80}\right) = 0.7619$$

Substituting into Equation (1):

$$\kappa = \frac{0.975 - 0.7619}{1 - 0.7619} = 0.895$$

The obtained κ = 0.895 indicates a high level of agreement beyond chance. Using the interpretation guidelines proposed by McHugh (2012) [23] (Table 2), this value falls within the "Strong" agreement category (0.80–0.90). This result demonstrates that the two experts evaluated the indicators with substantial consistency and supports the conclusion that the instrument's indicator-level judgements are reliable [32].

Table 2. Cohen's Kappa Interpretation

Value of Kappa	Level of Agreement	% of Data that are Reliable
0 – 0.20	None	0 – 4%
0.21 – 0.39	Minimal	4 – 15%
0.40 – 0.59	Weak	15 – 35%
0.60 – 0.79	Moderate	35 – 63%
0.80 – 0.90	Strong	64 – 81%
> 0.90	Almost Perfect	82 – 100%

Source: McHugh (2012) [23]

3.6. Developing of Smart City Readiness Measurement Tools

The development of the smart city readiness measurement tools adopts the approach of the Stages of Change Model (Transtheoretical Model), introduced [33] This model focuses on the gradual process of individual behavioral change, which unfolds through a series of well-defined stages. The Stages of Change Model provides a framework for understanding and assessing the readiness of individuals or groups to adopt change [33]. Its purpose is to facilitate change by offering intervention strategies tailored to the level of readiness exhibited by individuals within the change process [34]. In parallel, the assessment framework incorporates the Citiasia Nation Model, which emphasizes both readiness and performance as essential components of smart city development maturity. By integrating these models, the readiness assessment tool captures not only the physical and digital preparedness of a region but also its institutional and governance capacities [35].

This measurement concept is applied to assess regional readiness across five key aspects: infrastructure, facilities, public utilities, superstructure, and human resources. Through this approach, regions can be categorized into various levels of readiness, ranging from pre-contemplation as the lowest level to ready as the highest. This framework ensures that smart city development strategies are aligned with each region's capacity, allowing implementation to proceed effectively and sustainably. The following describes each readiness category as shown in Table 3.

Table 3. Assessment categorization

Grade	Categories	Explanation
1	Pre-contemplation	At this stage, the region is not yet prepared to implement a smart city. Representing the lowest level of readiness, the region has not demonstrated preparedness across the five required dimensions that support smart city development. Neither planning efforts nor supporting facilities necessary for smart city implementation are yet in place.
2	Contemplation	At this stage, the region enters an initial phase of readiness, beginning to recognize the importance of smart city implementation. The region starts to develop intentions to advance smart city initiatives in terms of infrastructure, facilities, and public utilities. Early discussions and information gathering also begin, aimed at preparing human

Grade	Categories	Explanation
		resources and regulatory frameworks (superstructure) to support smart city development within the region.
3	Preparation	At this stage, the region reaches an intermediate level of readiness, having identified and prepared the necessary steps for implementing a smart city. The local government has begun preparing supporting facilities, including infrastructure, facilities, and public utilities. In addition, preparations related to human resources and regulatory frameworks (superstructure) are also underway to strengthen overall smart city readiness.
4	Action	At this stage, the region enters an advanced level of readiness, characterized by the availability of programs designed to prepare the area prior to smart city implementation. The government has provided various forms of infrastructure, facilities, and public utilities to support smart city deployment. Additionally, programs have been introduced to help residents understand smart city concepts. Regulatory frameworks (superstructure) are also in place, although they are not yet fully aligned with national regulations.
5	Ready	At this stage, the region has achieved a high level of readiness for smart city implementation. In terms of infrastructure and facilities, all components are prepared to be integrated with smart city technologies. Public utilities that support smart city operations have also been established. From a human resources perspective, both the community and government personnel have been adequately prepared. As the legal foundation, the superstructure dimension has been developed to support smart city implementation. All five dimensions of smart city readiness in the region have been fulfilled and are aligned with national government regulations.

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The proposed measurement instrument incorporates an assessment (scoring) model developed using an ordinal scale. An ordinal scale is a type of measurement scale used to organize data based on order or ranking. In this scale, data are grouped into categories with a specific rank, but the scale does not indicate precise distances or intervals between the ranks [36]. Each parameter is assigned a value range from 1 to 5, with specific descriptions provided for each score. The assessment of smart city readiness in a city or regency is carried out by distributing the measurement instrument or questionnaire to the relevant government departments (those involved in regional smart city initiatives). The assessment stage of regional smart city readiness begins by calculating the capability score for each readiness dimension. The evaluation is obtained by computing the average score of all indicators within each dimension. Next, the resulting average scores are categorized according to the SPBE (Electronic-Based Government System) index. The SPBE index was developed to promote a governance system capable of utilizing technology optimally, transparently, and effectively, thereby fostering cities that are innovative, high-performing, adaptive, and dynamic [37], as shown in Table 4.

Table 4. Categorization of SPBE Index Values

No	Indeks Number	Predicate
1	4,2 – 5,0	Satisfactory
2	3,5 – < 4,2	Very Good
3	2,6 – < 3,5	Good
4	1,8 – < 2,6	Fair
5	< 1,8	Poor

Source: Kemenpan of Republic of Indonesia 2020

After obtaining the score for each readiness dimension, the assessment proceeds by calculating the overall regional readiness. This is done by computing the average of all dimensional scores divided by the total number of dimensions. Based on the resulting average value, the regional readiness level is then categorized according to the following readiness classifications, as shown in Table 5.

Table 5. Categorization of smart city readiness levels

No	Index Number	Level
1	4,2 – 5,0	Ready
2	3,5 – < 4,2	Action
3	2,6 – < 3,5	Preparation
4	1,8 – < 2,6	Contemplation
5	< 1,8	Pre-contemplation

For example, if a city achieves average scores of 4.3 for infrastructure, 4.1 for facilities, 3.8 for public utilities, 4.0 for human resources, and 4.2 for superstructure, the overall readiness score is calculated as the mean of these five dimensions, resulting in a score of 4.08. Based on the readiness classification, this city is categorized at the "Action" level. A city can be considered to have achieved smart city readiness if it attains an average score of 4.2 to 5.0 across all sub- dimenssion assessments namely infrastructure, facilities, public utilities, human resources, and superstructure and thus falls within the *ready* category.

A city is considered ready to implement a smart city when its physical systems, social systems, and digital systems have been prepared in an integrated manner. The city's physical systems include infrastructure such as buildings, bridges, power grids, and communication infrastructure that support city life. Social systems encompass various elements of society, including city government, communities, and individuals who interact in daily life. Digital systems include technologies such as sensors, computer networks, and data centers that enable efficient data integration and processing. These three systems must function synergistically thru cyberspace to realize a smart city that is responsive to the needs of its citizens [38].

3.7. Discussion

This study developed and validated a regulation-based smart city readiness model aligned with Government Regulation No. 59/2022 (PP No. 59/2022) to address the absence of a standardized, policy-aligned readiness instrument for Indonesian regions [10], [11]. Building on prior work that emphasises that smart city implementation requires readiness beyond technology alone—spanning infrastructure, institutions, and human resources [5], [6]—the findings confirm that readiness must be conceptualised as a multi-dimensional socio-

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technical condition rather than a narrow ICT capability [2], [3], [4]. Using a PRISMA-guided synthesis [13] and regulation-driven indicator mapping [24], the study moved from an initial pool of international and national readiness indicators to a locally operationalised instrument suitable for district/city assessment.

Based on expert judgement and content validation, the two evaluators showed a high level of consistency in assessing indicator relevance, culminating in the refinement of the original 80 indicators to 70 valid indicators across five regulation-defined dimensions: infrastructure, facilities, public utilities, human resources, and suprastructure (Figure 4). The exclusion of 10 indicators was primarily attributed to (i) regulatory non-essentiality (i.e., not required at district/city level) and (ii) feasibility and measurability constraints (i.e., absence of reliable institutional data). These deletion rationales are important because they demonstrate that policy-aligned readiness measurement is not only a question of conceptual completeness, but also of administrative feasibility and data governance capacity, which prior Indonesian case studies have repeatedly highlighted as an implementation barrier [9]. In other words, the validated indicator set reflects what can be credibly measured and acted upon within local government systems, rather than what may be desirable in idealised smart city templates.

Figure 4. Final evaluation of smart city readiness indicators and dimensions

The robustness of the expert-based validation process is reinforced by the inter-rater reliability results. Agreement between raters was evaluated using Cohen's Kappa [23], which accounts for chance agreement and is recommended when two raters assess categorical judgements [31]. The resulting kappa value of $\kappa = 0.895$ indicates strong agreement according to McHugh's interpretation thresholds [23], supporting the reliability of the indicator classification decisions and implying that the final indicator set can be considered dependable for readiness assessment purposes [32]. Together with face validity results indicating that the instrument is readable and implementable without specialised technical training, the findings suggest that the instrument has both methodological credibility and practical usability within government settings [21].

The primary theoretical contribution lies in operationalising Indonesia's regulatory definitions into measurable readiness indicators, thereby addressing a gap in prior readiness research that has largely remained case-specific or framework-driven without explicit alignment to national urban governance regulation [8], [9], [10]. While earlier scholarship recognises that readiness spans infrastructure, institutions, and human capability [5], [6], this study advances the literature by demonstrating how regulation can serve as a structuring logic for readiness measurement. The validated five-dimensional model provides a coherent conceptual bridge between global smart city readiness thinking and nationally defined urban components under PP No. 59/2022 [10]. As such, the model supports a more policy-grounded understanding of readiness that is directly actionable by regional governments tasked with implementing national mandates and programmes (e.g., "Gerakan Menuju 100 Smart City") [7].

From an implementation perspective, the findings confirm that the readiness dimensions are interdependent, and weaknesses in one domain can constrain progress in others. For example, improvements in infrastructure and public utilities—often treated as "technical readiness"—are unlikely to translate into effective smart city outcomes without complementary human resource capability and a supportive suprastructure (policy, coordination mechanisms, institutional arrangements). This aligns with the broader position that smart cities function as integrated systems where technological adoption must be embedded within governance and institutional capacity [2], [3], [4]. The refined indicator set therefore provides local governments with a structured tool to (i) diagnose readiness gaps, (ii) prioritise investments and capability-building, and (iii) sequence implementation strategies in a realistic way.

Importantly, the model's link to staged readiness categories (pre-contemplation → ready) strengthens its practical value by enabling regions to interpret their readiness as a developmental trajectory, consistent with the Stages of Change Model [33], [34]. In addition, the incorporation of the Citiasia Nation Model perspective—which frames readiness and performance as complementary maturity components—supports assessment beyond physical/digital preparedness toward institutional and governance capacity [35]. Finally, the proposed scoring logic—using an ordinal scale [36] and mapping outcomes to SPBE-based performance predicates [37]—supports benchmarking and comparison across cities/regencies, which is essential for programme governance and resource targeting at national scale.

Compared with international readiness frameworks (e.g., ASCIMER and TOE-based readiness approaches), the model developed in this study places greater emphasis on regulatory alignment and governance-operational feasibility. International models often prioritise technology, organisational capability, and enabling environments [8], [14], yet they may not adequately capture how national legal definitions shape what local governments are expected to provide and measure [10]. The current study's contribution is therefore not to replace global frameworks, but to contextualise and translate their most relevant elements into a regulation-grounded instrument that local governments can apply consistently under PP No. 59/2022. This also responds directly to the Indonesian implementation challenge highlighted in prior studies—namely that readiness assessments can fail when indicators cannot be supported by existing institutional data systems or governance arrangements [9].

Despite these contributions, the study has limitations. First, expert validation relied on two raters, which—while producing strong agreement—still constrains diversity of perspectives across regions and administrative contexts. Expanding validation to a larger panel (e.g., central government agencies, provincial planners, municipal implementers, and SPBE assessors) would strengthen generalisability and further refine indicator wording and feasibility. Second, the current validation emphasises content/face validity and inter-rater reliability; additional empirical testing across multiple municipalities is needed to evaluate instrument performance under real implementation conditions and to assess whether readiness scores relate to smart city outcomes, as suggested by concerns about implementation failures linked to governance, sustainability, and capability gaps [11]. Future work could also apply longitudinal measurement using the staged readiness framework [33], [34] to track readiness improvement over time and examine whether regions progress systematically through the proposed readiness levels.

4. CONCLUSION

This study developed a smart city readiness assessment model explicitly aligned with Indonesia's urban governance framework, with specific reference to Government Regulation No. 59 of 2022. The objective was achieved through the systematic refinement and validation of 70 readiness indicators organised across five regulation-derived dimensions—infrastructure, facilities, public utilities, human resources, and suprastructure—resulting in a standardised, policy-aligned measurement instrument suitable for Indonesian local governments. By embedding regulatory and governance requirements into indicator design, the proposed model extends widely used readiness frameworks (e.g., ASCIMER and TOE), which often underrepresent national legal and institutional structures. Methodological rigor was ensured through the integrated application of Design Science Research, a PRISMA-guided systematic literature review, expert-based content validation, and inter-rater reliability testing, which demonstrated strong agreement ($\kappa = 0.895$). Practically, the instrument provides local governments with a structured tool to diagnose readiness gaps, prioritise interventions, support evidence-based planning, and strengthen the sustainability of smart city implementation.

Despite these contributions, the study has limitations. Validation was based on expert judgement from two domain experts, and the instrument has not yet been empirically tested across multiple regions. Future research should therefore apply the model across diverse regional contexts, employ additional statistical validation (e.g., exploratory and confirmatory factor analysis), incorporate longitudinal measurement to capture readiness dynamics over time, and examine whether readiness levels predict smart city implementation performance and outcomes.

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