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# Smart Resilience City As An Approach To Improve Disaster Risk Reduction

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## ABSTRACT
Cities confront massive issues like Disasters, climate change, urbanization, population growth, and economic growth; it is necessary to reduce their impact to the minimum possible. To accomplish this, A smart, resilient society intended to manage cities using Big Data, the Internet of Things (IoT), and intelligent information technologies to improve the ability to resist, absorb, and adapt to external changes resulting in urban resilience. Beyond that, constructing a smart, resilient city is a more advanced strategy for reducing vulnerabilities to emergencies like the COVID-19 pandemic and natural disasters like earthquakes and tsunamis. This study proposes a conceptual design for smart resilience cities and explores how a system can improve risk reduction and adaptation approaches and natural disaster recovery. Using various examples, the various states how smart cities' characteristics help cities be more resilient to disasters. The paper explains the differences and similarities between a smart city and a resilient city.

**Keywords***:* Smart city, Disasters Risk, Resilience

**المدينة الذكية المرونة كنهج لتحسين الحد من مخاطر الكوارث**

**ملخص البحث**

تواجه المدن قضايا هائلة مثل الكوارث وتغير المناخ والتحضر والنمو السكاني والنمو الاقتصادي؛ من الضروري تقليل تأثيرها إلى أدنى حد ممكن. لتحقيق ذلك، يهدف مجتمع ذكي ومرن إلى إدارة المدن باستخدام البيانات الضخمة وإنترنت الأشياء (IoT) وتقنيات المعلومات الذكية لتحسين القدرة على المقاومة والاستيعاب والتكيف مع التغيرات الخارجية التي تؤدي إلى المرونة الحضرية. علاوة على ذلك، يعد بناء مدينة ذكية ومرنة استراتيجية أكثر تقدمًا للحد من التعرض لحالات الطوارئ مثل جائحة COVID-19 والكوارث الطبيعية مثل الزلازل وأمواج تسونامي. تقترح هذه الدراسة تصميمًا مفاهيميًا لمدن المرونة الذكية وتستكشف كيف يمكن للنظام تحسين أساليب الحد من المخاطر والتكيف والتعافي من الكوارث الطبيعية. باستخدام أمثلة مختلفة، توضح الأنواع المختلفة كيف تساعد خصائص المدن الذكية المدن على أن تكون أكثر مقاومة للكوارث. تشرح الورقة أوجه التشابه والاختلاف بين المدينة الذكية والمدينة الصامدة.

**الكلمات الدالة:** المدينة الذكية، مخاطر الكوارث، المرونة

## INTRODUCTION

The idea of a Smart city goes back to the rising societal complexity. In urban areas, ecosystems are significant, making sustainability an essential aspect. The ecosystem suffers from economic disruption, a high urbanization rate, climate, and, rapid population rise. These factors impede growth, and cities become restless and disorganized. Smart city has resulted in using technology to solve all these problems and address them more smartly. Hence, the concept of smart cities (Clarke, 2013). All of the above results in a significant challenge to the traditional infrastructure of cities, and the solution is to make it effective, more efficient, and rationalize with smart systems. Experts believe that if cities do not become smart, they are on the verge of collapse. (Figure 1) shows the world's population and cities by urban settlement size

category, 1970, 1990, 2018, and 2030, where global urban population growth correlates with urban growth. Many smart cities lack the mechanisms of urban resilience necessary to face risks and disasters, whether natural or human, due to climate changes, economic, social, and environmental fluctuations, or in the face of diseases and epidemics. It hinders the ability of these cities to respond and adapt and then quickly recover from the effects of these crises and disasters.

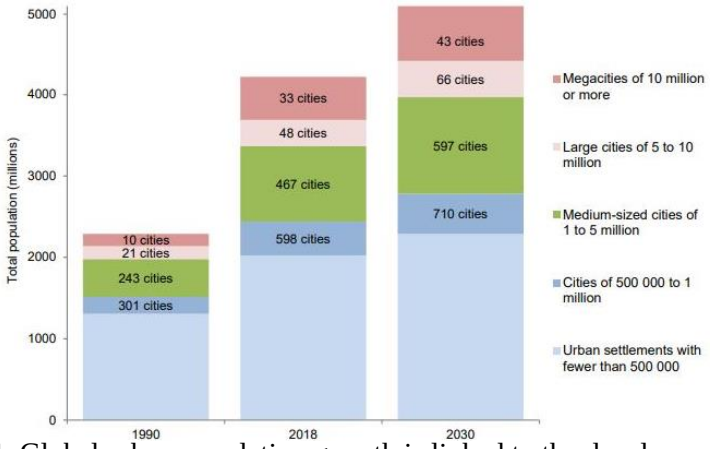


**Figure 1.** Global urban population growth is linked to the development of cities
Source:(United Nations, 2018)

Modern technology and Information and Communication Technology (ICT) are the main aspects of the smart city concept. The researchers also stress in smart city planning the necessity of resilience. A city must have the ability to adapt to different conditions, especially if technology fails, whether as a result of artificial or natural disasters. Because a well-functioning town depends on the integration, interconnected performance, and capabilities of complex infrastructure systems and services, enhancing its performance will increase resilience and improve disaster management (National Academies of Sciences, 2017). Integration and interconnected performance help improve the city's capacity and thus increase resilience and enhance disaster management. This paper is concerned with the smart city and the resilient city concepts. A review of current literature led to this conclusion; it analyzes the aspects of the relationship between the two images and highlights how the smart city concept can interpret as a process directed to make cities "more resilient and livable, and thus, respond faster. To issues."

## 1. MATERIALS AND METHODS

The selection of alternative codes and indicators is the first stage in achieving the research's purpose. Every indicator system's notion and goal are identified and assessed. The technique organizes sub-processes that overlap to allow the necessary topic matter to address (Gatzen et al., 2013) of the chosen systems to thoroughly evaluate and construct an indicator pool. The next stage is to create and create an indicator framework in terms of global evaluation criteria that already exist that can systematically and cohesively determine assessments of resilient and smart cities. The last stage is to choose indications using the organized system as a guide. The suggested indicator is used in urban planning research to assess city resiliency and smartness, as illustrated in (Figure 2). As a result, combining smart and resilience indicators allows city administrators, urban planners, and academics to concentrate on two realistic frameworks for developing a system that may increase risk reduction, adaptation, and natural catastrophe recovery.


**Figure 2.** Phases of research to develop a smart, resilient city framework (Source: Author,2022)

### 1.1 From Smart to Resilience

Citizens may feel confident that essential services, including public transportation, communication, power and water supply, healthcare, and education, will be delivered without interruption of vital infrastructure in a safe and resilient city with a smart city (Abou El Seoud, 2019). Fuel stations, power generation, healthcare, transportation, banking sectors, governmental institutions, military installations, water sources, and bridges are essential infrastructures. Risks to the smart, sustainable city network of integrated systems, whether natural or artificial, can interrupt operational continuity (Zhu et al., 2019).

Smart cities are made up of infrastructure and physical and IT services that can maintain social cohesiveness while tackling and deploying innovation and improving cognitive abilities. These characteristics are extremely similar to the new notion of city resilience, which is redefining the smart city model. Individuals, communities, institutions, and infrastructures all play a role in ensuring resilience (Baron, 2012). In the context of cities, we define "resilience" like a city's ability to improve as a human settlement hub, cultural, and productivity advancement in the face of difficulties for example climate change, population expansion, and globalization (Roggema, 2020).

### 1.2 Smart City

According to the ITU's intelligent, sustainable city group, a smart city is a forward-thinking city that uses ICT to enhance the quality of life, urban processes, service efficiency, and competitiveness while meeting current and future economic, social, and environmental demands (ISO/IEC JTC 1, 2015). It believes that a smart city is a route of urban expansion dedicated to enhancing urban management efficiency, attaining sustainable urban development, and improving the quality of life of city people via the development and use of ICT (Ramaswami et al., 2016). This definition plays an excellent guiding role in developing the theory of smart cities and constructing various cities, The International Electrotechnical Commission and other organizations and academics have acknowledged it (International Organization for Standardization (ISO), 2018).

Smart cities combine physical and information technology (IT) systems and infrastructure that can secure social cohesion, and improve cognitive abilities through tackling and using innovation. These features align with the rising idea of city resilience, which is reshaping the smart city paradigm. Individuals, communities, institutions, and infrastructures all have a role in ensuring resilience (Ashmore et al., 2017).

### 1.3 Smart City Indicators and Critical Factors

To guarantee that a wide range of techniques for judging smartness, including a

thorough search approach, was performed. To account for various developers' use of different phrases while discussing assessment procedures, the study string contained the terms 'Tool,' 'Toolkit,' 'Index,' 'Framework,' and 'Indicator Set' are just a few examples. A preliminary list of eight tools compiled. The requirements used to determine which criteria of evaluation were appropriate for inclusion in the study:

- Assessment should be the primary emphasis of the tools.
- They should contain a set of criteria, measurements, or indications for evaluation.
- They should address more than one facet or subject of intelligence.
- Accessible guidelines and documentation for the tools should be available. Table 1 contains a comprehensive list of these tools. The table also shows the release year and the developer and main emphasis.

**Table 1.** This study explored a list of smart city indicator systems.

| Indicator systems | Year | The main focus | Developer |
|---|---|---|---|
| **Lisbon ranking smart sustainable cities (**LRSC**)** | 2019 | Multiple dimensions (Economy, Environment, Society, and Culture) | (Akande et al., 2019) |
| **Smart Sustainable Cities China (**SSCC**)** | 2019 | Multiple dimensions (Innovation in technology, the smart economy, smart infrastructure, smart services, smart transportation, and the smart environment) | (Li et al., 2019) |
| **IoT-Enabled Smart city framework (**IES-City) | 2018 | Multiple dimensions (Economy, Environment, Society, Smart Infrastructure, Governance, and Service Delivery) | The National Institute of Standards and Technology (Burns, 2018) |
| **United 4 Smart Sustainable Cities (**U4SSC2**)** | 2017 | Multiple dimensions of cities that are smart and sustainable (Economy, Environment, Society, and Culture) | (United Nations Economic Commission for Europe (UNECE), 2017) |
| **Networked Society City Index (**NSCI**)** | 2016 | The relationship between ICT maturity and long-term development of TBL | (Ericsson, 2016) |
| **International Telecommunication Union (ITU-T)** | 2015 | Multiple dimensions related to Cities that are smart and sustainable (ICT, environmental sustainability, productivity, quality of life, fairness and social inclusion, and physical infrastructure) | ITU-T Smart Sustainable Cities Focus Group (Sang & Li, 2019) |
| **Smart cities Ranking of European medium-sized cities (**EU-MSC**)** | 2014 | Multiple dimensions (Economy, people, governance, mobility, environment, livelihood) | TU Vienna collaborates with the University of Ljubljana and the Technical University of Delft. |
| **Smart City Index (**Boyd Cohen**)** | 2014 | Multiple dimensions (Economy, government, people, livelihood, mobility, environment) | (Cohen, 2015) |

Source: Author, 2022

## 1.4 Resilience of Cities Against Natural Disasters

Resilience is a multiple meanings concept with diverse definitions depending on the field. Robustness, stress resistance, and minimal disruption are all important in some fields, such as engineering. In other words, robust systems should be well equipped to withstand shocks without severe functionality loss and quickly recover to equilibrium points (Hosseini et al., 2016). As a result, such systems require capacity for planning and preparation (before a disaster), absorption (during a crisis), and recovery (after a

disaster) (Sharifi & Yamagata, 2016).
We used a definition that encompassed all of these approaches for our investigation. The National Academies of Sciences, Engineering, and Medicine provided the definition, which has been widely used across various fields "The ability to adapt and plan for negative conditions, absorb and recover from them, and more successfully adjust to them"(Cutter et al., 2013). This concept was appropriate for the goal of this research, which was to discuss contributions at different phases of crisis management.
In an urban context, we define "resilience" as a city's potential to thrive as a hub of human habitation, production, and cultural progress despite challenges including climate change, population increase, and globalization.

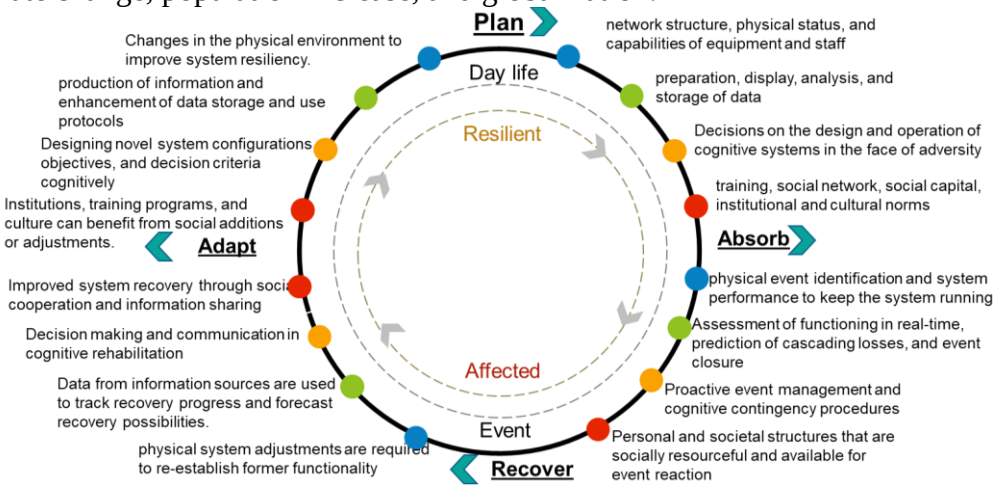


**Figure 3.** Resilience Circle
(Source: Author,2021)

According to the literature, resilience should not view as a single-disciplinary issue (Royal HaskoningDHV, n.d.), and instead, as a "concept" characterized by four critical skills: (1) planning/preparation; (2) absorbing; (3) recovering; and (4) adapting Every city's four critical socio-technical dimensions must address these competencies: Physical, information, cognitive, and social factors all play a role.
Figure 3 depicts the top of the circle showing the normal position. When the trigger level hits a specified point, such as rising water levels or wind pressures, the preparation phase begins with active monitoring of changes, taking preventative steps, increasing activity levels, and even warning of emergency measures. The preventive activities cover in the upper right corner. The extreme weather event or hazard represent at the bottom of the circle. The reaction phase focuses on disaster management and emergency assistance. Following the crisis, the recovery phase (top left) concentrates on rebuilding better (Adeola & Picou, 2012). Cities around the world are learning from one another and developing a road plan for becoming more resilient to physical, social, and economic obstacles caused by both unexpected calamities (The Rockefeller Foundation, 2014).

### 1.5 Resilience and its Indicators

The last ten years have been critical in driving the global community toward more resilient, sustainable, and inclusive societies. Local governments are the most in touch with people and their needs, allowing them to lead bottom-up initiatives and address global concerns where they have the most impact (Cutter et al., 2010).
Various developers may utilize a variety of methods terminology to refer to their assessment methods, therefore the search strings took that into consideration as well (tool, toolkit, model, framework, manual, and index, for example). These papers' titles

and abstracts examine if they report on resilience assessment tools as shown in Table 2. The study's scope is manageable; here, attention will be focused on those techniques that attempt to assess the community's resilience as a whole system.

**Table 2.** Explored a list of resilience indicator systems**.**

| Indicator systems | Year | The main focus | Developer(s) |
|---|---|---|---|
| **Australian National Disaster Resilience Index (**ANDRI**)** | 2020 | **The resilience of society** In the face of natural hazards. It is based on two sets of capabilities: adaptive capacities and adaptive capacities. | (Parsons et al., 2020) |
| **Resilient Capacity Index (**RCI**)** | 2018 | The way to assess the region's resilience is its quality to deal with future challenges and respond effectively to future pressures. | Resilience Index (Edgemon et al., 2018) |
| **Baseline Resilience Indicators Communities (**BRIC) | 2014 | **The resilience of society** It is a complex process of interactions between different social systems, each with its own form and function | (Cutter et al., 2014) |
| **CommunityDisaster Resilience Index (**CDRI) | 2010 | **Multiple dimensions** Social capital, economic capital, human capital, physical capital | Coastal Services Center and NOAA. Center (Peacock, 2010) |
| **Community Resilience Index (**CRI2**)** | 2010 | **Multiple dimensions** Cultural, physiological, economic, institutional, and natural factors all have a role. | Dr. Susan Cutter and her colleagues at the Hazard & Vulnerability Research Institute at the University of South Carolina |
| **Disaster Resilience of Place (**DROP) | 2010 | **Resilience is a set of capabilities** That can be strengthened through interventions and policies, which help build and strengthen the capacity to respond and recover from disasters. | Hyogo Framework (Marzi et al., 2019) |

Source: Author, 2022

## 2. RESULTS AND DISCUSSION

### 2.1 Urban Resilience to Support the Smart City: Disaster Risk Reduction

The COVID-19 epidemic has claimed many lives and livelihoods since its appearance in late 2019. The epidemic and its consequences provide a chance to consider cities and their resilience to shocks and pressures. They explored many challenges relating to economics, environmental management, smart cities, social inequities, and a sense of community and transportation that have consequences for urban resilience. Key elements connected to these topics have substantial consequences for planning, absorption, recovery, and adaptive skills. The implications are incredibly substantial for absorption and recovery capacity, highlighting the importance of proper planning and design strategies for confining the virus and promoting a speedy return to everyday circumstances (UN-Habitat, 2020).

Smart and resilient cities advocate integrating and giving a more flexible strategy for dealing with the COVID-19 in the post-pandemic phase. The smart city system's ICT systems, hardware, and software, such as the positive cases tracking system, may assist and gather data for enhancing urban resilience. A vast volume of data and information collected by the internet of things (IoT) devices with intelligent features incorporated can serve as a solid basis for incorporating "smart" into regular operations and attaining "resilience" in emergencies (Zhu et al., 2020).

## 2.2 Smart Resilience Indicator

Every evaluation strategy builds on the foundation of indicators. The chosen schemes assess indicators, with themes at the top, factors in the center, and indicators at the bottom. Themes are broad categories that pertain to critical components of smart city development aims. Each subject may include many variables that help cities develop more detailed plans. All indicators obtain from the various schemes after detecting overlapping or repetition.

Consequently, the study's next step is to figure out how the recommended indicator systems should be structured. Table 3 shows the recommended approach will use to classify the indications. The result will serve as the foundation for developing a comprehensive strategy for identifying and assessing smart and resilient communities. Because various schemes may use different descriptions for comparable indicators. For example, the proportion of gross domestic spending on R&D, total R&D expenditure, and investment in supporting researchers are all variations of the 'R&D expenditure' statistic. The extent of coverage of a particular indicator calculates by dividing the total number of times contained in the selected schemes by the total number of schemes after all selected schemes analyze. The content analysis repeats twice to improve counting accuracy (Organisation for Economic Co-operation and Development (OECD), 2021).

**Table 3.** Shows the integration between indicators of smart and resilience concepts.

| Sector | Dimensions | Factors | Indications | Smart | Resilient |
|---|---|---|---|---|---|
| Economy | Information and Communication Technology | ICT infrastructure | 1. The existence of wired and wireless networks | √ | |
| | | | 2. Existence of WANS, LANS | √ | |
| | | | 3. Mobile broadband coverage rate (3G, 4G, 5G, mobile broadband speed | √ | |
| | | | 4. The presence of sensors and surveillance cameras | √ | |
| | | | 5. The presence of the Internet at home | √ | |
| | | | 6. Coverage of Wi-Fi networks in public places | √ | |
| | | | 7. The smart city's integrated platform for actual operation and management | √ | |
| | | | 8. Social and economic access to digital technologies, and the affordability of ICTs | √ | |
| | | | 9. Enhancing Infrastructure Efficiency (Technology Modernization, Measurement) | √ | √ |
| | | | 10. Emergency communication infrastructure (before, during, and after a disaster) | | √ |
| | | wastewater supply | 1. Smart water meters | √ | |
| | | | 2. Monitoring water supply and ICT | √ | |
| | | | 3 Technological controls of the sewage/rainwater system | √ | |
| | | electricity supply | 1. Smart Electricity Meters | √ | |
| | | | 2. Electricity supply monitoring | √ | |
| | | | 3. Intelligent load distribution | √ | |
| | | Transport | 1. Dynamic public transportation information | √ | |
| | | | 2. Traffic control and control | √ | |
| | | | 3. Control and management of intersections | √ | |
| | | Public sector | 1. Availability and dissemination of data to make information open to the public | √ | |
| | | | 2. E-Government | √ | √ |
| | | | 3. Public sector e-procurement | √ | √ |
| | | | 4. Public-private partnership | | √ |
| | Product... | Innovation | 1. Research and development expenditures | √ | √ |
| | | | 2. Patents | √ | |

| Sector | Dimensions | Factors | Indications | Smart | Resilient |
|---|---|---|---|---|---|
| | | | 3. Project funding (public/private, etc.) for smart cities. | √ | √ |
| | | | 4. The share of e-commerce and e-commerce transactions | √ | |
| | | | 5. Number of new businesses and companies registered annually | √ | √ |
| | | | 6. Investing in green jobs and the green economy (self-sufficiency, urban agriculture) | | √ |
| | | | 7. Diversified economic structure and livelihood strategies | | √ |
| | | Employment and unemployment | 1. Unemployment rate | √ | |
| | | | 2. Youth unemployment rate | √ | |
| | | | 3. Employment rates and opportunities | √ | √ |
| | | | 4. Job intensity (proximity to housing and work; extent of commuting outside the home) | | √ |
| | | | 5. The working population's age distribution | | √ |
| | | | 6. Qualifications of people in their working years | | √ |
| | | | 7. Employment in the ICT sector | √ | |
| | | | 8. Savings by individuals and communities (stock of supplies, cash, etc.) | | √ |
| | | | 9. Achieving a balance between supply and demand in the local labor market | | √ |
| | | | 10. GDP per worker | √ | |
| | **infrastructure** | Water supply and sanitation | 1. Water main network | √ | |
| | | | 2. Drinking water network and sources | √ | |
| | | | 3. Water supply control | √ | |
| | | | 4. Wastewater collection and treatment | √ | |
| | | | 5. Domestic sanitation | √ | |
| | | electricity supply | 1. The number of times the power network is cut off | √ | |
| | | | 2. The time of power outage | √ | |
| | | | 3. Sources of electricity | √ | |
| | | Transport | 1. Intelligent/automatic street/pedestrian lighting management system using ICT | √ | |
| | | | 2. The public transportation system, its quality, diversity and multimodal | √ | |
| | | | 3. In public transportation, performance, safety, and efficiency are essential factors | √ | √ |
| | | | 4. Share transportation | √ | √ |
| | | | 5. Guide and indication about transportation and parking services | √ | |
| | | | 6. Car and bike sharing services | √ | |
| | | | 7. Cycling infrastructure options and facilities | √ | |
| | | | 8. Green transportation modes (percentage of green vehicles, electric vehicles, etc.) | √ | |
| | | | 9. Availability of applications (parking, multimodal transportation, car sharing, etc.) | √ | |
| | | | 10. Efficiency of road traffic, trip duration, congestion levels, and congestion management | √ | |
| | | | 11. Real-time, intelligent, and automated traffic management sensing and monitoring | √ | |
| | | | 12. Operation and maintenance of efficient transmission | √ | |
| | | Urban/Integrated Planning | 1. Pedestrian infrastructure | √ | |
| | | | 2. Street type and connection | √ | |
| | | | 3. Urban development and spatial planning | √ | |
| | | | 4. Comprehensive city monitoring and data management | √ | √ |
| | | | 5. Green and blue infrastructure | | √ |
| | | | 6. Online access and coordination of all urban public services | √ | √ |
| | | | 7. At various levels, there is easy access to essential requirements and services (food, water, shelter, energy, health, education) | √ | |
| | | | 8. Site selection and avoidance of danger areas and habitat areas (flood plains, prone to flooding; exposed coastal area, green fields) | | √ |
| | | | 9. sustainability of public buildings | √ | |
| | | | 10. Integrated Building Management Systems in Public Buildings | | √ |
| **Environme** | **Environme** | air quality | 1. Air pollution | √ | |
| | | | 2. Greenhouse gas emissions | √ | |

| Sector | Dimensions | Factors | Indications | Smart | Resilient |
|---|---|---|---|---|---|
| | | water and sanitation | 1. Quality of water resources and water bodies and quality control | √ | |
| | | | 2. Water consumption yearly (m3 per capita, per GDP) | √ | |
| | | | 3. Water creation, delivery, and usage that is efficient | √ | |
| | | | 4. Wastewater treatment | √ | |
| | | Waste | 1. Management of materials and resources (production, consumption, conservation, recycling) | √ | √ |
| | | | 2. Efficient and intelligent collection, disposal and treatment of solid waste | √ | |
| | | environmental quality | 1. Exposure to electromagnetic fields | √ | |
| | | | 2. Exposure to noise | √ | |
| | | | 3. Initiatives for green infrastructure and green cities | √ | √ |
| | | | 4. Activities and initiatives to safeguard the environment and ecosystems | √ | √ |
| | | | 5. Sustainable management of natural resources | √ | √ |
| | | Public places and | 1. Green/blue spaces (per person) | √ | √ |
| | | | 2. Easy access to the green area | √ | √ |
| | | | 3. Natural protected areas | √ | √ |
| | | | 4. Recreational facilities | √ | √ |
| | | energy | 1. Renewable energy consumption | √ | |
| | | | 2. Electricity consumption | √ | |
| | | | 3. Energy intensity for the economy | √ | |
| | | | 4. Resource availability and accessibility (air, energy, water, food, soil, etc.) | | √ |
| | | | 5. Energy management and consumption that is efficient (buildings, public places, etc.) | √ | |
| | | | 6. Use of ICTs for energy management, monitoring, and savings (e.g., smart metering) | √ | |
| Social and cultural | Education, health and culture | education | 1. Students' use of ICT | √ | √ |
| | | | 2. E-learning and distant education systems' availability and penetration | √ | √ |
| | | | 3. School attendance | √ | √ |
| | | | 4. Higher education degrees | √ | √ |
| | | | 5. Adult Literacy | √ | √ |
| | | health | 1. Electronic health records/cards | √ | |
| | | | 2. Life expectancy | √ | |
| | | | 3. Death rate | √ | |
| | | | 4. Medication Accreditation (Diagnostic and Telemedicine) | √ | |
| | | | 5. Health care services and infrastructure for the individual | √ | |
| | | | 6. Physical and mental health | | √ |
| | | | 7. Preventive health measures | | √ |
| | | | 8. Responsive health measures | | √ |
| | | | 9. Health insurance/public health coverage | √ | |
| | | culture | 1. Cultural expenses | √ | |
| | | | 2. Positive social, cultural and behavioral norms | | √ |
| | | | 3. Cultural infrastructure (attractions, sports infrastructure). | √ | |
| | | | 4. The size and quality of community centers and public entertainment venues are important considerations. | √ | |
| | | | 5. Protection and management of cultural heritage | √ | √ |
| | Safety, housing and social inclusion | housing | 1. Quality of housing (space per capita), reduction of slums | √ | √ |
| | | | 2. Housing expenses | √ | √ |
| | | Social integration | 1. Gender equality in income | √ | √ |
| | | | 2. Gender, racial, and cultural equality (access to opportunities) | √ | √ |
| | | | 3. Attachment and a sense of belonging and interdependence to society | | √ |
| | | | 4. Volunteering and civic participation in social networks | | √ |
| | | | 5. Poverty rate | √ | |
| | | | 6. Availability of child care | √ | |
| | | Safety and security | 1. Disaster prevention, prediction, control, and emergency response using ICTs | √ | √ |
| | | | 2. Deaths related to natural disasters | √ | |
| | | | 3. Economic losses associated with disasters | √ | |

| Sector | Dimensions | Factors | Indications | Smart | Resilient |
|---|---|---|---|---|---|
| | | | 4. Disaster risk planning, control and management | √ | |
| | | | 5. Population living in disaster-prone areas | √ | |
| | | | 6. Emergency service response time | √ | |
| | | | 7. Use of technology and information and communication technology to predict, prevent and combat crime | √ | √ |
| | | | 8. Security services such as the police | | √ |
| | | | 9. Community safety and crime rate (for example, the number of crimes per 100,000 inhabitants) | √ | √ |
| | | | 10. Digital security, information privacy and security management (against hackers, etc.) | √ | √ |
| | | | 11. Traffic accident deaths | √ | |
| | | | 12. ICT and smart systems (such as RFID) are being used to improve well-being. | √ | |
| | | | 13. Satisfaction with urban services and wellbeing | √ | |

Source: Author, 2022

Smart Resilience indicators can significantly increase the resilience of essential infrastructures such as energy and water supplies, mobility, information, and communication grids, engaging stakeholders. The indicator's strategy takes into account human difficulties as well as societal and economic concerns. Three pillars support the proposed Smart Resilient City Measurement Framework: Improve people's well-being and build more inclusive, sustainable, and resilient societies, depending on which smart cities leverage resilience.

1- At the city level, indications indicate the degree of digitization and digital innovation (input and output indicators)
2- Indicators of various stakeholders' involvement in the smart city's construction
3- Smart city aspects and indicators that influence the three primary aims of the smart city, namely well-being, inclusion, sustainability, and resilience.

### 2.2.1 Economy

Indicators about how smart solutions might improve the economic elements of sustainable development include this area. It focuses on encouraging innovation, creating new job possibilities, bolstering the city's competitive advantage in the global economy, improving productivity, and boosting resiliency. Indicators connected to transportation and ICT infrastructure are included in the mobility subject. Smart solutions for fostering equitable and low-carbon transportation services by leveraging smart infrastructure that manages in an integrated manner are the focus of transportation-related indicators. The ICT-related metrics include the provision of suitable ICT infrastructure for allowing smart solutions, as well as infrastructure management and accessibility initiatives.

### 2.2.2 Environment

Smart cities expect to offer new answers to various environmental issues communities face. As a result, it is no surprise that the "environment" subject has many indicators. These indicators cover environmental monitoring and protection, green infrastructure, urban city planning, resource consumption, resource planning (energy, water, and waste), and environmental quality.

### 2.2.3 Society and culture

The end-users of smart city projects are people. As a result, smart city programs prioritize improving people's society and culture. This is evident in smart city evaluation software. They contain metrics for smart solutions' ability to strengthen social cohesion, citizen involvement, justice, cultural activities, skills, and capacities, and create safe and healthy communities, among other things.

## 3. IDENTIFING THE CRITERIA FOR PICKING THE CASE STUDY CITIES

The researcher chose the case study cities from a list of common smart and resilient cities as shown in Figure 4. Since the emergence of the COVID-19 pandemic, a deep dive into data shows how urban residents are attaching increasing importance to the economic, environmental, and Society-Culture dimensions of their cities and the extent to which they have achieved the indicators of the smart city resilient.


**Figure 4.** Smart and Resilient city around the world
(Source: Author,2022)

### 3.1. The Selected Case Study of Daegu, Korea

The journey of Daegu since the city's Smart City Plan was unveiled to the public in 2014 was chronicled in this case study. Were put in place to aid in evaluating the city's existing smart city initiatives, benchmark performance, and highlight successful best practices to promote the worldwide applicability of these smart resilience indicators. Because it is one of the first smart, sustainable, the insights from the implementation process will serve as a guide for other cities in the region. Table 4 shows the city profile (Park et al., 2020) .

### 3.1.1 COVID-19 in Daegu, south Korea

On January 20, 2020, the first patient confirmed as a corvid-19 case in Korea was disclosed. As a result, with the help of the World Health Organization (WHO) and the Chinese health authorities, the KCDC (Korea Center for Disease Control) strengthened the quarantine and screening measures for passengers entering Wuhan at entry points (Smart City Korea, 2022). The Republic of Korea's (ROK) management of the COVID-19 epidemic recognized its successful end without resorting to stringent border controls or civilian isolation. The Republic of Korea has maintained a high degree of transparency and openness in handling the epidemic. One of the potential examples for a successful response to the COVID-19 pandemic is the Korean case study (You, 2020). The following sections will look at how Daegu's smart city relate to each of the three components of indicator as shown in Figure 5:

### 3.1.2 Economy

Previously, the Republic of Korea supported eco-city efforts to make its cities carbon-neutral and sustainable. The succeeding National Smart City Programmed, which intends to use state-of-the-art technology for overall urban planning, development, and administration, was built on constructing eco-cities (to safeguard the natural environment). Cost-effective urban services related to transportation, manufacturing, and education have been introduced (based on the linkage between data and service systems) and supported by a high level of network connectivity, the introduction of 5G, and high penetration of mobile devices as part of this nationwide Smart City Program. A high level of coordination between public and commercial entities providing various services has also enabled the deployment of a secure IT infrastructure that protects personal data (Ramraj, 2020).

### 3.1.3 Environment

The possibility of utilizing new technologies for community-based environmental monitoring has opened up new pathways for real-time monitoring of numerous environmental factors, which may positively influence the city's quality of life through communication and knowledge sharing. The smart resilience indicator's second dimension, which is concerned with environmental elements, is devoted to sustainability and monitoring environmental conditions (including air and water quality) and livability (e.g., accessibility to adequate green space) (Cho, 2016).

### 3.1.4 Society and Culture

ICT apps are the key to disseminating public information about government services and performance, and ICT applications may provide a simple platform for large-scale citizen participation. The influence of ICTs on increasing fairness, governance, resilience, information flow, and public involvement is the third pillar of smart resilience indicators. This part also looks at Daegu's technological activities when the city was on the verge of being hit by the COVID-19 pandemic 2020 (Yang et al., 2021).


**Figure 5.** Key Performance Indicators (a) Economy indicators (b) Environment indicators (c) Society and Culture indicators in Daegu, south Korea (Source *(International Telecommunication Union (ITU), 2021)*)

### 3.2. The Selected Case Study of Dubai, UAE

Dubai, which is currently one of the most significant smart cities in modern society, not just in the Arab world but also on a worldwide scale, is a leading example. It is now one of the world's most influential corporate centers and a significant economic and

trade hub. It has also seen a substantial increase in population due to two factors: a decrease in newborn mortality rates resulting from improved healthcare facilities and economic expansion resulting from the development of the oil sector (Salem, 2016). Table 4 shows the city profile.

**Table 4.** Information about Dubai, UAE and Daegu, Korea city

| City profile | Dubai, UAE | Daegu, Korea city |
|---|---|---|
| Inhabitants | 2,964,000 | 2 418 246 |
| Area | 4.114 km2 | 883 km2 |
| City GDP | $410.06 | USD 50 6.3 |
| Inflation Rate | 2.5% | 0.50 % |
| Household Income | US$81,000 | USD 42 699 |

### 3.2.1 COVID-19 in Dubai, UAE

The National Crisis and Emergency Management Authority oversees the UAE's emergency response system. The UAE government quickly issued the first alarm about the new coronavirus epidemic, even before WHO designated it a public health emergency of worldwide significance .

The UAE has a well-developed, government-funded healthcare system and private healthcare institutions that provide a high level of treatment to the populace. Throughout this epidemic, the whole healthcare system was ready and notified, with processes in place for effective crisis management (Al Hosany et al., 2021).

The following sections will look at how Dubai's existing smart city relate to each of the three components1) economy, 2) environment, and 3) society and culture.

### 3.2.2 Economy

Dubai has grown into a prominent economic center with a vibrant and diverse economy in the previous three decades. The city has been praised for its excellent infrastructure, worldwide vision, and liberal government actions that attract business and encourage the growth of new businesses.

Smart Dubai collaborates with the Ministry of Economy to convert Dubai's economy into a diverse, creative, and service-based economy to improve the business climate and accelerate product development. The Economic Development Board and its agencies achieve this through developing economic policies and plans, identifying and supporting the growth of essential industries, and providing a service to domestic and foreign investors and enterprises (Jawad, 2019) .

### 3.2.3 Environment

Dubai has environmental difficulties comparable to those faced by other major global cities, such as air pollution, garbage management, and excessive CO2 emissions. The UAE, the Dubai Water and Electricity Authority, and the Dubai Supreme Council of Energy work together to address these environmental issues. These groups influence the city's environmental sustainability and engage with Smart Dubai to find potential for ICT-related service launches. Management procedures, environmental resources, and linked infrastructures benefit from these services.

### 3.2.4 Society and Culture

In order to be inclusive, a smart sustainable city must provide new sorts of technology to disadvantaged or underrepresented populations. Information and communication technology (ICT) can give tools that let citizens participate more actively. Technology skepticism or people that are scared by new technical tools are examples of barriers to technology adoption. This is a significant societal problem that necessitates developing

measures to increase trust, address public concerns about technological progress, and encourage the use of new technology.

The case studies is analyzed by studing a set of elemnts that achieve the research objectives, including smart resilience indicators and their impact on improving the status of cities in the face of disasters, as shown in Table 5.

**Table 5.** Assessment Smart resilience indicator in Dubai and Daegu, Korea

| Sector | Dimensions | Factors | Indications | Case Study 1 | | | Case Study 2 | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Mainly | second | poorly | Mainly | second | poorly |
| Economy | Information and Communication Technology | ICT infrastructure | 1. The existence of wired and wireless networks | ● | | | ● | | |
| | | | 2. Existence of WANS, LANS | ● | | | ● | | |
| | | | 3. Mobile broadband coverage rate (3G, 4G, 5G, mobile broadband speed | ● | | | ● | | |
| | | | 4. The presence of sensors and surveillance cameras | ● | | | | ◉ | |
| | | | 5. The presence of the Internet at home | ● | | | ● | | |
| | | | 6. Coverage of Wi-Fi networks in public places | | | ◉ | | ◉ | |
| | | | 7. The integrated platform for real-time operation and management of the smart city | ● | | | ● | | |
| | | | 8. Social and economic access to digital technologies, and the affordability of ICTs | ● | | | ● | | |
| | | | 9. Enhancing Infrastructure Efficiency (Technology Modernization, Measurement) | ● | | | ● | | |
| | | | 10. Emergency communication infrastructure (before, during and after a disaster) | ● | | | ● | | |
| | | wastewater | 1. Smart water meters | | ◉ | | | ◉ | |
| | | | 2. Monitoring water supply and ICT | ● | | | ● | | |
| | | | 3 Technological controls of the sewage/rain water system | ● | | | ● | | |
| | | electricity supply | 1. Smart Electricity Meters | ● | | | ● | | |
| | | | 2. Electricity supply monitoring | | ◉ | | | ◉ | |
| | | | 3. Intelligent load distribution | | ◉ | | | ◉ | |
| | | Transport | 1. Dynamic public transportation information | ● | | | ● | | |
| | | | 2. Traffic control and control | ● | | | ● | | |
| | | | 3. Control and management of intersections | | ◉ | | | ◉ | |
| | | Public sector | 1. Availability and dissemination of data to make information open to the public | | | ◉ | | | ◉ |
| | | | 2. E-Government | ● | | | ● | | |
| | | | 3. Public sector e-procurement | | | ◉ | | ◉ | |
| | | | 4. Public-private partnership | ● | | | | ◉ | |
| | Productivity | Innovation and the knowledge economy | 1. Research and development expenditures | ● | | | ● | | |
| | | | 2. Patents | ● | | | ● | | |
| | | | 3. Financing smart city projects (public/private financing, etc.). | ● | | | | ◉ | |
| | | | 4. The share of e-commerce and e-commerce transactions | ● | | | | ◉ | |
| | | | 5. Number of new businesses and companies registered annually | ● | | | | ◉ | |
| | | | 6. Investing in green jobs and the green economy (self-sufficiency, urban agriculture) | ● | | | ● | | |
| | | | 7. Diversified economic structure and livelihood strategies | ● | | | ● | | |
| | | Employment and unemployment | 1. Unemployment rate | ● | | | ● | | |
| | | | 2. Youth unemployment rate | ● | | | ● | | |
| | | | 3. Employment rates and opportunities | ● | | | | ◉ | |
| | | | 4. Job intensity (proximity to housing and work; extent of commuting outside the home) | ● | | | | ◉ | |
| | | | 5. Age structure of the working population | ● | | | ● | | |
| | | | 6. Qualifications of the working age population | ● | | | ● | | |
| | | | 7. Employment in the ICT sector | | | ◉ | | | ◉ |
| | | | 8. Individual and community savings (stock of supplies, cash, etc.) | ● | | | ● | | |
| | | | 9. Achieving a balance between supply and demand in the local labor market | ● | | | ● | | |

| Sector | Dimensions | Factors | Indications | Case Study 1 | | | Case Study 2 | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Mainly | second | poorly | Mainly | second | poorly |
| Environmental | | | 10. GDP per worker | ● | | | ● | | |
| | infrastructure | Water supply and | 1. Water main network | ● | | | ● | | |
| | | | 2. Drinking water network and sources | ● | | | ● | | |
| | | | 3. Water supply control | ● | | | ● | | |
| | | | 4. Wastewater collection and treatment | ● | | | ● | | |
| | | | 5. Domestic sanitation | | | ○ | | | ○ |
| | | electricity | 1. The number of times the power network is cut off | ● | | | ● | | |
| | | | 2. The time of power outage | ● | | | ● | | |
| | | | 3. Sources of electricity | ● | | | ● | | |
| | | Transport | 1. Intelligent/automatic street/Pedestrian lighting management system using ICT | ● | | | ● | | |
| | | | 2. The public transportation system, its quality, diversity and multimodal | ● | | | ● | | |
| | | | 3. Performance, safety and efficiency in public transportation | ● | | | ● | | |
| | | | 4. Share transportation | | | ○ | | ◐ | |
| | | | 5. Guide and indication about transportation and parking services | ● | | | | ◐ | |
| | | | 6. Car and bike sharing services | | | ○ | | | ○ |
| | | | 7. Cycling infrastructure options and facilities | | | ○ | | ◐ | |
| | | | 8. Green transportation modes (e.g., percentage of green vehicles, electric vehicles, etc.) | | ◐ | | | ◐ | |
| | | | 9. Availability of applications (parking, multimodal transportation, car sharing, etc.) | ● | | | ● | | |
| | | | 10. Road traffic efficiency, travel time, congestion levels, congestion management | ● | | | ● | | |
| | | | 11. Sensing and monitoring of real-time, intelligent, and automated traffic management | ● | | | ● | | |
| | | | 12. Operation and maintenance of efficient transmission | ● | | | ● | | |
| | | Urban/Integrated Planning | 1. Pedestrian infrastructure | | ◐ | | | ◐ | |
| | | | 2. Street type and connection | ● | | | ● | | |
| | | | 3. Urban development and spatial planning | ● | | | ● | | |
| | | | 4. Comprehensive city monitoring and data management | ● | | | ● | | |
| | | | 5. Online access and coordination of all urban public services | ● | | | ● | | |
| | | | 6. Easy access to basic needs and services at various stages (food, water, shelter, energy, health, education) | ● | | | ● | | |
| | | | 7. Site selection and avoidance of danger areas and habitat areas (flood plains, prone to flooding; exposed coastal area, green fields) | ● | | | ● | | |
| | | | 8. sustainability of public buildings | | ◐ | | | ◐ | |
| | | | 9. Integrated Building Management Systems in Public Buildings | | ◐ | | | ◐ | |
| | Environmental and Energy Sustainability | air qualit | 1. Air pollution | ● | | | | ◐ | |
| | | | 2. Greenhouse gas emissions | ● | | | ● | | |
| | | water and sanitation | 1. Quality of water resources and water bodies and quality control | ● | | | ● | | |
| | | | 2. Total annual water consumption (m3 per capita, per GDP) | | | ○ | | | ○ |
| | | | 3. Efficient generation, distribution and use of water | ● | | | ● | | |
| | | | 4. Wastewater treatment | ● | | | ● | | |
| | | Waste | 1. Material and resource management (production, consumption, conservation, recycling) | ● | | | ● | | |
| | | | 2. Efficient and intelligent collection, disposal and treatment of solid waste | ● | | | ● | | |
| | | environmental quality | 1. Exposure to electromagnetic fields | ● | | | ● | | |
| | | | 2. Exposure to noise | ● | | | ● | | |
| | | | 3. Green infrastructure and green city initiatives | ● | | | ● | | |
| | | | 4. Environmental/ecosystem protection activities and efforts | ● | | | ● | | |
| | | | 5. Sustainable management of natural resources | ● | | | ● | | |
| | | Public places | 1. Green/blue spaces (per person) | | | ○ | | ◐ | |
| | | | 2. Easy access to the green area | ● | | | ● | | |
| | | | 3. Natural protected areas | ● | | | ● | | |
| | | | 4. Recreational facilities | ● | | | ● | | |

| Sector | Dimensions | Factors | Indications | Case Study 1 | | | Case Study 2 | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Mainly | second | poorly | Mainly | second | poorly |
| | | Energy | 1. Renewable energy consumption | | | ○ | | | ○ |
| | | | 2. Electricity consumption | | | ○ | | | ○ |
| | | | 3. Energy intensity for the economy | ● | | | ● | | |
| | | | 4. Availability and accessibility of resources (air, energy, water, food, soil, etc.) | ● | | | ● | | |
| | | | 5. Efficient management and use of energy (buildings, public places, etc.) | | | ○ | | | ○ |
| | | | 6. Use of ICTs for energy management, monitoring and savings (e.g., smart metering) | ● | | | ● | | |
| Social and Cultural | Education, health and culture | education | 1. Students' use of ICT | ● | | | ● | | |
| | | | 2. Availability and penetration of e-learning and distance education systems | ● | | | | ◉ | |
| | | | 3. School attendance | ● | | | ● | | |
| | | | 4. Higher education degrees | ● | | | ● | | |
| | | | 5. Adult Literacy | ● | | | ● | | |
| | | health | 1. Electronic health records/cards | ● | | | | ◉ | |
| | | | 2. Life expectancy | ● | | | ● | | |
| | | | 3. Death rate | ● | | | ● | | |
| | | | 4. Medication Accreditation (Diagnostic and Telemedicine) | ● | | | ● | | |
| | | | 5. Health care services and infrastructure for the individual | ● | | | ● | | |
| | | | 6. Physical and mental health | | ◉ | | | ◉ | |
| | | | 7. Preventive health measures | ● | | | ● | | |
| | | | 8. Responsive health measures | ● | | | ● | | |
| | | | 9. Health insurance/public health coverage | ● | | | ● | | |
| | | culture | 1. Cultural expenses | | | ○ | | | ○ |
| | | | 2. Positive social, cultural and behavioral norms | ● | | | ● | | |
| | | | 3. Cultural infrastructure (attractions, sports infrastructure). | | | | | | |
| | | | 4. Size and quality of community centers and public entertainment venues | ● | | | ● | | |
| | | | 5. Protection and management of cultural heritage | ● | | | ● | | |
| | Safety, housing and social inclusion | housing | 1. Quality of housing (space per capita), reduction of slums | ● | | | | ◉ | |
| | | | 2. Housing expenses | ● | | | ● | | |
| | | Social integration | 1. Gender equality in income | | | ○ | | | ○ |
| | | | 2. Racial, cultural and gender equality (access to opportunities) | ● | | | ● | | |
| | | | 3. Attachment and a sense of belonging and interdependence to society | ● | | | ● | | |
| | | | 4. Volunteering and civic participation in social networks | ● | | | ● | | |
| | | | 5. Poverty rate | | ◉ | | | ◉ | |
| | | | 6. Availability of child care | ● | | | ● | | |
| | | Safety and security | 1. The use of ICTs for disaster prevention, prediction, control and emergency response | ● | | | ● | | |
| | | | 2. Deaths related to natural disasters | ● | | | ● | | |
| | | | 3. Economic losses associated with disasters | ● | | | ● | | |
| | | | 4. Disaster risk planning, control and management | | | | | | |
| | | | 5. Population living in disaster-prone areas | ● | | | ● | | |
| | | | 6. Emergency service response time | | ◉ | | | ◉ | |
| | | | 7. Use of technology and information and communication technology to predict, prevent and combat crime | | | | | | |
| | | | 8. Security services such as the police | ● | | | ● | | |
| | | | 9. Community safety and crime rate (for example, the number of crimes per 100,000 inhabitants) | | ◉ | | | ◉ | |
| | | | 10. Information privacy and security management, digital security (against hackers, etc.) | | | | | | |
| | | | 11. Traffic accident deaths | | | ○ | | | ○ |
| | | | 12. Use of ICT and smart technologies (such as RFID) to enhance well-being | ● | | | ● | | |
| | | | 13. Satisfaction with quality of life and urban services | ● | | | ● | | |

●Mainly use ◉Secondary use ○Poorly use

Source: Author, 2022

The following can be clarified through the analytical study of a city using the extent to which it has achieved the indicators of resilience smart cities. Daegu has shown to be an appropriate location for adopting the smart, resilient indicator, with its area leading smart resilience city vision and goals and receiving cooperation from various government agencies operating in many fields and local telecom providers.

The following findings are based on Daegu's investigation of the indicators and Daegu's smart, sustainable city policies, goals, and efforts. These results will serve as a "knowledge center" for all other developing smart, resilient cities in Asia:

- Daegu has created a successful, sustainable city model, which includes a clear strategy, well-defined programs, and projects that significantly influence the residents' quality of life.
- Another great practice that other aspiring smart cities could replicate is Daegu's focus on using new and emerging technology to solve city problems and improve the lives of its residents.
- Daegu involves its residents to improve the effectiveness of the COVID-19 pandemic response. Trust and involvement created via the municipal strategic planning process and initiatives like the Urban Issue Finding Team are critical to safeguarding public health.

## 4. Conclusion

The emergence of cities as a future development hotspot has prompted cities worldwide to explore innovative approaches to study urban patterns to achieve sustainable urban goals. To better direct and analyze the effect of urban growth, various evaluation methodologies, inspections, and indicator systems are now in place.

However, the broad range of smartness is the current planning trend, which is related to other notions like sustainability or resiliency, resulting in the Smart Resilient City. The concept supports urban sustainability without providing a concrete operational model to demonstrate its efficacy, yet it is adopted for future urban policies and activities. This article suggested a complete indicator through the conceptual suggestion of chosen methods to assess indicators in Figure 6. By providing an indicator for a smart-resilient urban agenda, the innovative framework aspires to contribute to urban sustainability possibly. Smart and resilient cities are sometimes conceptualized as different ideas in contemporary urban planning. Independent research uses to define its indications, with just a handful focused on a complete index for smart and resilient communities.

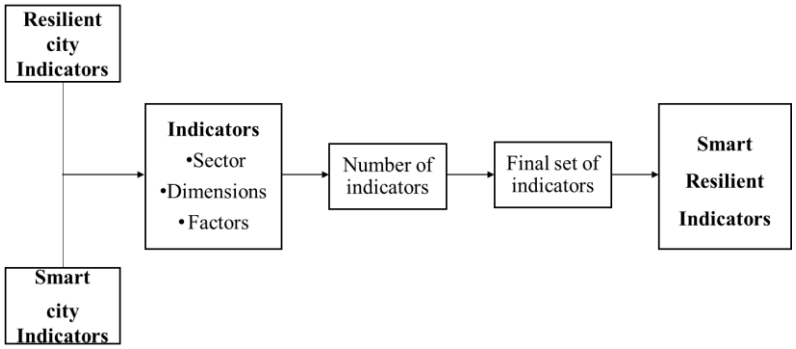


**Figure 6.** Evaluation of performance in the direction of a smart resilient city (Source: Author,2022)

This strong indicator result offers a framework for decision-makers and city planners to improve the quality of urban development. The indicators are benchmarked as an integrated network to quantify the city's smart and resilient characteristics.

Finally, more investigation and modification may be conducted in a practical case study, mainly because the urban system introduces complexity that challenges the desired sustainable conclusion. Despite its limitations, the report opens up new research opportunities because each case study must address a different issue, contributing to the update of smart, resilient city indicators.

## RECOMMENDATION

To increase the status and degree of smart indicators in cities, the government, the business sector, and eventually the people must pursue many policies and activities in tandem. The city should move toward smart resilient city standards based on these results to solve its existing and future difficulties. Before addressing real solutions, our proposals include requirements and contexts that must address.

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