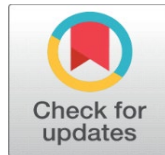# SMART CITIES: AN EMPIRICAL STUDY OF DEFINITIONS

Ashish Batra [1] ✉ iD, Pankaj Chhabra [2] ✉ iD

[1] Ph.D. Research Scholar, Guru Ramdas School of Planning, Guru Nanak Dev University, Amritsar, Punjab, India
[2] Department of Architecture, Guru Nanak Dev University, Amritsar, Punjab India

ABSTRACT

This research has been done alongside the objective of set up a clear definition of smart cities that could possibly utilized globally. Despite a lot of material on smart cities that are accessible, there is no defined, widely used set of terminology that would assist in accurately defining a "Smart City".

Around 115 current smart cities definitions were analysed and examined by utilizing as a guideline the themes and attributes of smart cities. These definitions have been acquired from numerous sources such as user-centric definitions, company/corporate profiles, national and international organizations (United Nations, ITU, Indian Smart Cities Mission, etc.), government initiatives, academia & research communities, standards development organizations, and trade associations. A list of thirty important terms that need to be included in a standardized definition was determined, and important indicators and categories were also established. Finally, to conclude on the basis of the given analyses, a suggested definition for the "smart city" was given by the following:

An innovative city is known as a "smart city" if it adopts ICTs ("information and communication technologies") including innovative methods to enhance wellbeing, the effectiveness of urban services and environment, while simultaneously fulfilling the social, environmental, and economic requirements of both the present as well as the future generations.

This derived definition is such a definition which can be generalized for any smart city with basic fundamentals terms mentioned in it and can be adopted widely throughout the world.

Keywords: Definition, Smart Cities, Review, Analysis

1. INTRODUCTION

In India the urban population is around 410 million people, which is around 32% of the total population. As per UN reports it is expected to touch 814 million by 2050, which means around 50% of the total. In the same report is estimated that by 2050, around 70% of world's population would live in urban areas. Small cities had a net gain in population of 1.3 billion from 1950 to 2020, which is twice the population of big cities (570 million) or medium cities (632 million).

People relocate to metropolitan regions to enhance their lifestyles and access better employment possibilities. However, the growing population in metropolitan areas creates complicated problems including traffic congestion and increased

demand for limited natural resources like education, sanitation, water, and energy, along with healthcare services, among other issues.

ICTs may provide more cost-effective and environmentally friendly solutions to some of the aforementioned urban concerns. ICTs' potential to address environmental problems has not yet been fully determined. ICTs may be able to help in many different areas, such as water resources management, energy efficacy, & solid waste management, public transportation infrastructure that reduces traffic jams, the development of ICT infrastructure, and controlling its effect on the environment with regard to EMF ("Electromagnetic Field") concerns, visual aspects, as well as air quality monitoring Sharma (2019).

2. MOTIVATION AND OBJECTIVES FOR A COMPREHENSIVE DEFINITION

2.1. GOALS

Numerous cities throughout the globe have running behind the word "Smart City", branding their cities as "smart" in one way or another, as a result of rising urbanization & the clear necessity to build a sustainable model to help expected expansion.

This study's main objective is to explain the numerous definitions of "Smart Cities" on the basis of publicly available material, conduct a study, and then provide a comprehensive and formal description of the ITU word "Smart City". A defined set of terms for "Smart Cities" would be helpful for word as well as for ICT infrastructure, KPIs, metrics, and smart city regulations.

2.2. ABSENCE OF STEREOTYPE TERMINOLOGIES

There is a lot of information available about smart cities, but there isn't a set of acceptable words that might be used tremendous properly define the phrase "Smart City." There are several descriptors, traits, definitions, indices, and indicators based on the perspective taken.

It is necessary to compare and contrast several definitions and attributes of smart as well as sustainable cities, before settling on a definition that is anticipated to serve as a great foundation for the growth of conceptual smart cities. What features would constitute a "Smart City"? Which factor is more important: quality of life, innovation, natural resources, environment, economics, people, infrastructure, transport, communication, technology, or government? What conditions must be met to define a city as smart?

2.3. REQUIREMENT FOR AN EXTENSIVE GLOBAL DEFINITION

As mentioned in the part above, a "Smart City" definition must be established. The process of coming up with a new definition will undoubtedly open the door to a more structured approach to the term's definition as well as to the ICT infrastructure, policies, metrics, and KPIs for smart cities. Another aspect that is also critical is that among researchers, many study groups are working with themes that intersect or overlap with smart cities. Many scholars are also focusing on smart cities, but from a different perspective and using a different paradigm.

3. OBSERVATION FROM LITERATURE

The literature discussing smart cities led to the following preliminary findings. Many definitions of smart cities exist depending on the lens or point of view used. This is essential to keep in mind since it will help explain why and what certain traits are important. The following categories may be used to categorize the many subjective perspectives on what makes a smart city:

- Infrastructure;
- Attributes; and
- Themes.

The foundation of this research is a mix of intelligence and smarts in an urban setting with sustainability as a major background. Remember that this research is a summary of what is common in the open literature rather than a paper that makes recommendations for best practices.

3.1. ATTRIBUTES

In terms of characterizing a smart city, the following characteristics emerge often in the literature:

- **Sustainability –** This relates to urban planning and governance, climate and energy change, waste, and pollution, social as well as economic issues;
- **Quality of life –**It is a repetitive topic. One purpose of a smart city might be to enhance the lifestyle for both financial and emotional well-being;
- **Urban aspects –** This covers a variety of elements and measures, such as governance, economics, sustainability, infrastructure; technology; and
- **Smartness or intelligence –** A "smart" city demonstrates an explicit or implicit to raise social, environmental, and economic standards. Smart environment, lifestyle, mobility, governance, people, along with economy are all often cited examples of smartness.

3.2. CORE THEMES

A smart city should focus on the following four areas:

- **Society –** The city exists for its residents, often known as "citizens";
- **Economy –** The city should be able to prosper in all areas, including employment, economic development, and finance;
- **Environment –** The city's operations should be sustainable for both the current and coming generations; and
- **Governance –** The capacity of the city to administer policies and coordinate the many aspects must be robust.

3.3. INFRASTRUCTURE

The best way to define infrastructure in an urban setting is in terms of its three components: physical, service/social, and digital or ICT. "The fundamental definition of "physical" is "physical infrastructure"– such as factories, water, gas pipelines, electric lines, roads, train tracks, buildings, and the like. The social and service infrastructure sits on top of the physical infrastructure and probably includes mass transit, utilities (such as electricity, water, and gas), education, and

healthcare. The infrastructure of ICT is crucial for an effective smart city since it serves as the "glue" that unites the other components and serves as a platform for the whole system. The central component, or ICT infrastructure, serves as the hub and coordinates all of the many interactions among different physical infrastructures as well as core components.

4. DEFINITION AND ANALYSIS
4.1. INFORMATION SOURCES

The present section includes definitions and related characteristics in terms of smart city metrics, indices, and rankings. For the purposes of this research, a variety of articles were gathered from different databases on the Internet. These papers were examined and analysed to bring together a broad variety of viewpoints and guarantee the definition of smart cities. These definitions came from many different sources, such as:

- Definitions that focus on users (from reputable market research companies);
- Trade organizations
- Organizations that develop standards.
- National & international organizations (Indian Smart Cities Mission, ITU, United Nations, etc.);
- Government programs, such as the EU;
- company/Corporate profiles; and
- Academic and scientific communities.

4.2. METHODOLOGY

Because of the availability of extensive data, and around 115 different definitions for smart cities, it is desired to perform a good research to bring out a standard description of a smart city. The next sections elaborate on the study's results, which identified the most salient characteristics and terminology associated with a smart city. Below given is the methodology adopted for the research:

- A list of important terms was retrieved and tabulated for each definition. Because of limitation of pages, the table consists of only 5 sample definitions.
- Keywords were then categorized as shown in the third column of the table.
- Certain words, like "smart", "sustainable" and "city," are implied and have been used in all description; as a result, they aren't gathered as separate keywords.

4.3. APPROACH

The research has been conducted using a systematic methodology, which included:

1) **Hierarchical approach (top to bottom) –** Rankings, indices and indicators; and
2) **Hierarchical approach (bottom to top) –** Descriptors, definitions and attributes.

Multiple terms and their combinations were employed throughout the study's search for primary sources. The most common search terms were ranking, success, example, solution, methodology, urban, intelligent, ICT, characteristics, indicator, index, attributes, definition, city (ies), environment, sustainable, and smart. From these many sources, a thorough study of several key terms, qualities, and views was conducted. A broad collection of definitions has been produced using this method, and the research now has a feeling of "completeness" or comprehensiveness.

The samples below (eight) show many keywords that were discovered and recorded based on the definitions. The complete list of definitions is very exhaustive (around 115) and cannot be presented here.

Table 1

Table 1 Samples of Definitions with Extracted Keywords

Citation	Defined Smart City	Keywords extracted
Giffinger, Rudolf, *et al*. "Smart Cities Ranking of European Medium-sized Cities." "Centre of Regional Science, Vienna UT, Oct. 2007. Page 10. Web. Last Accessed 05 Feb. 2023". "http://www.smart-cities.eu/download/smart_cities_final_report.pdf"	A city well performing in a forward-looking way in [economy, people, governance, mobility, environment, and living] built on the smart combination of endowments and activities of self-decisive, independent and aware citizens."	People, environment, independent citizens, self-decisive citizens, aware citizens, governance, forward-looking, quality of living, mobility, and economy.
Cohen, Boyd. "The Top 10 Smart Cities on The Planet." Fast Company, 11 Jan. 2011. Web. Last accessed 05 Feb. 2023. "http://www.fastcoexist.com/1679127/the-top-10-smart-cities-on-the-planet".	ICT is used by smart cities to utilize resources more intelligently and efficiently, which saves money and energy, improves service delivery as well as life quality, and reduces environmental impact. These benefits encourage innovation and a low-carbon economy.	low carbon economy, innovation, enhanced service delivery, environment, quality of life, energy efficiency, energy savings, cost efficiency, and ICT.
IBM. "India Needs Sustainable Cities". "IBM SMARTER PLANET, Web. Last accessed 05 Feb. 2023". "http://www.ibm.com/smarterplanet/in/en/sustainable_cities/ideas/".	In terms of cost & time, replacing the existing city infrastructures is frequently unachievable. But due to recent technological developments, we can add new intelligence to our old infrastructures. We must digitize and link them for our systems to perceive, analyze, as well as react intelligently and integrate data to the demands of their respective jurisdictions. In other words, we could revive them and make them smarter and more effective. Cities may expand and maintain their residents' quality of life in this way.	Sustainability, quality of life, growth, efficiency, responsiveness, integrating data, analysing data, connecting systems, and technology.
Nfuka, E. N., Rusu, L., Critical success factors for effective IT governance in the public sector organization in a developing: The case of Tanzania. Albino et al. (2015)	"A city striving to make itself smarter (more efficient, sustainable, equitable and liveable)."	Efficient, Sustainable, QoL, society, ICT, technology, liveable.
Antrobus, D., *Smart green cities: from modernization to resilience*, Urban Research and Practice, Vol. 4, July 2011.	Smart cities should be centred around ecological modernization with an emphasis on business opportunities associated with a move to low carbon economy.	Environment, business, resources, ecological, efficient, low carbon economy.

Monedero, D. R., Bartoli, A., Hernandez-Saerrano, J., Forne, J., Soriano, M. (2013). Allwinkle and Cruickshank (2011)	Key aspect of smart cities is a plan for efficient management of utilities enabled by technologies such as those entailing smart metering of the residential consumption of electricity, water or gas.	Technology, utilities, efficient, water, electricity.
Hodkinson, S. (2011). Batty et al. (2012)	The terms "smart" and "intelligent" have become part of the language of urbanization policy, referring to the clever use of IT to improve the productivity of a city's essential infrastructure and services and to reduce energy inputs and CO_2 outputs in response to global climate change.	ICT, infrastructure productivity, services, low carbon, environment.
Paroutis. S., Bennett, Heracleous, L. (2012). Bayulken and Huisingh (2015)	IBM Smarter Cities Initiative: " 1) is a long term process aiming to transform city based technologies and, in the process, help cities achieve their strategic vision; 2) recognizes that the needs and aspirations of each city may be very different; 3) requires partnerships (across many clients and with other delivery partners) to achieve the desired large scale transformations; 4) is based heavily on dimensions from IBM's global Smarter Planet strategy of which there are many applications (smart education systems, cloud computing, risk assessments, ICT based platform for exchange of ideas etc.)."	Vision, solutions, design, management, business, education, ICT, technology.

5. OUTCOMES
5.1. KEYWORD RESEARCH USING VARIOUS DEFINITIONS

All of the classifications were examined to determine the most important terms and attributes of a smart city. Certain terms, like "smart" and "city," are implied and stated in practical descriptions; as a result, they have not been specifically recorded as independent keywords.

A total of 50 keywords were found, and it seemed that they were used more than once in each definition that was examined. These 50 terms appeared in 726 different occurrences overall (as shown in Table 2). These are shown in the table below to show the proportional contribution and frequency of repetition of these keywords throughout all 100+ definitions. A visual depicting the relative value of the various keywords has been created on the basis of literature research. The importance of a word increases with font size.

Figure 1

Figure 1 Collage of Keywords

Table 2 displays a quantitative study of several keywords as well as the frequency with which they appeared in the documents under examination.

Table 2

Table 2 List of Keywords, Total Occurrences, and Percentage of Occurrence			
S. No.	Keyword extracted	Total Occurrences	% Occurrence
1	Transport	18	2.5%
2	Mobility	14	1.9%
3	Competitive	5	0.7%
4	Business	13	1.8%
5	Investments	9	1.2%
6	Economy	34	4.7%
7	Vision	1	0.1%
8	Solutions	4	0.6%
9	Public	6	0.8%
10	Operational	1	0.1%
11	Capital	4	0.6%
12	Management	20	2.8%
13	Governance and Administration	35	4.8%
14	Natural	11	1.5%
15	Resources	27	3.7%
16	Environment	22	3.0%
17	Optimal	2	0.3%
18	Adaptable	3	0.4%
19	sustainable	28	3.9%
20	Efficient	24	3.3%
21	Participatory	3	0.4%
22	Aware	2	0.3%
23	Innovation	15	2.1%
24	Actively	4	0.6%

25	Society	6	0.8%
26	Urban	16	2.2%
27	People	36	5.0%
28	Accessible	2	0.3%
29	Community	5	0.7%
30	Design	4	0.6%
31	Advanced	1	0.1%
32	Systems	34	4.7%
33	Integrate	22	3.0%
34	Intelligent	16	2.2%
35	Communication	15	2.1%
36	Information	24	3.3%
37	Interconnected	1	0.1%
38	Technology	42	5.8%
39	ICT	27	3.7%
40	Modern	2	0.3%
41	Electricity	3	0.4%
42	Water	16	2.2%
43	Energy	17	2.3%
44	Education	16	2.2%
45	Utilities	3	0.4%
46	Health, Safety, and Security	26	3.6%
47	Buildings	17	2.3%
48	Services	10	1.4%
49	Development	16	2.2%
50	Quality of Life	44	6.1%
	Total	726	100%

5.2. GROUPING OF KEYWORDS

To better comprehend the relative significance of the various categories and keywords, certain logical groupings have been formed, as shown in Table 3, and the various keywords have been mapped into the groupings (properly color-coded).

Table 3

Table 3 Logical Groupings

Category	% Occurrence
Mobility	4%
Economy & Finance	8%
Governance, administration, and management	10%
Environment & sustainability	17%
Society, citizens, people,	12%
Information, intelligence, communication, ICT	26%
Infrastructure and services	17%
Quality of life and lifestyle	6%
Total	**100%**

A literature search was done to find the best way to characterize each of the aforementioned keyword groupings to reduce subjectivity. Maintaining a baseline of what each of those terms means is crucial.

ICT/Communication/Intelligence/Information: ICT offers a range of services including transportation, health care, and security for residents, enhanced & affordable power supply for businesses, e-commerce and remote working for enterprises, and communications and entertainment for people Building Ireland's Smart Economy (2008), Defined by the International Telecommunication Union (ITU)'s (n.d.), Dhingra and Chattopadhyay (2016), Velazquez et al. (2018).

Infrastructure: It consists of the fundamental institutional and physical frameworks required for society's and businesses' day-to-day operations, as well as the facilities and services that maintain the economy running Chourabi et al. (2012), Harrison and Onnelly (2011).

Sustainability/Environment: As described using WWF, UNEP, as well as IUCN: "Sustainability means enhancings human well-being while remaining within the bounds of supportive atmosphere Hodkinson (2014), Hu et al. (2016). The "World Commission on Environment and Development" ICT Behind Cities of the Future. Nokia (2023), IUCN/UNEP/WWF (1991) describes sustainability as a thought of expansion that "serves current requirements without compromising the capacity of future generations to do the same" Lara et al. (2016), Llacuna et al. (2015).

Society/Citizens/People: Smart people are the defining element between a smart and a digital city. In terms of human capital, important factors are social integration, lifelong learning, education level, and skills. McKinsey Global Institute. Mckinsey Report (2018), Monedero et al. (2013).

Lifestyle/Quality of life: The WHO ("World Health Organization") describes the lifestyle as "Individuals' views of where they are in life in relation to value and culture systems". These comprise their relationship to objectives, concerns, and expectations Neirotti et al. (2014), Nfuka and Rusu (2010).

Administration/Management/Governance: Political and active engagement, citizen services along with smart use of e-government are all components of smart governance O'Grady and O'Hare (2012), Organization for Economic Cooperation and Development (OECD) (n.d.), Oxford Dictionaries (2023).

Economy/Resources: The smart economy combines effective components of the innovation/idea economy with the business economy. It also offers a first-rate environment that emphasizes social cohesiveness and energy security Paroutis et al. (2012), Rana et al. (2018).

Mobility: Smart mobility facilitates the movement of people & goods while boosting economic, environmental, as well as human resources by focusing on comfortable and accessible multimodal transport (maintaining safety and moving at the appropriate pace) Smart Cities Study (n.d.), Smart City Mobility (2010).

5.3. ESSENTIAL TERMS FOR A STANDARDIZED DEFINITION

Based on all the study done previously, utilizing the key categories and fundamental keyword indicators the following 30 essential terms must be included for a "smart city".

Table 4

Table 4		
1. Security	11. Citizen	21. Water
2. Scalable	12. Education	22. Utilities and energy
3. Safe	13. Employment	23. Transportation and mobility
4. Resilient	14. Environmental	

5. Reliable
6. ICT
7. Growth
8. Economic
9. Adaptable
10. Accessible

15. Medical
16. Physical and service infrastructure
17. Physical safety
18. Standard of living
19. Welfare
20. Well-being

24. Telecommunications
25. Standardization
26. Regulatory and compliance
27. Policies and processes
28. Natural and man-made disasters
29. Manufacturing
30. Governance

6. RECOMMENDED DEFINITION
6.1. THE STANDARDS FOR DEFINING

Following a thorough examination of the keywords used in 115 definitions of a "smart city", the following criteria were established to best characterize one:

Key groups or categories

- Economy/Resources;
- Environment/Sustainable;
- Governance/Management/Administration ;
- ICT/ Information/ Intelligence/Communication
- Infrastructure & services ;
- Mobility.
- People/ Society/Citizens; and
- Lifestyle/Quality of life.

Categories on the basis of key indicators

Smart Economy, mobility, living, people, sustainability and environment, Smart governance.

Important terms to use

A list of thirty terms was chosen as being crucial to include in the "standardized definition" of a smart city. Specifications are given in section 5.3.

6.2. SPECIFICATIONS

The following may serve as the foundation for a "smart city" definition based on the analyses covered in this research. A "smart city" makes effective use of its ICT infrastructure in a safe, secure, accessible, scalable, reliable, adaptable, and resilient way to:

- Ensure real economic development that results in improved living conditions and job opportunities for its people;
- Establish a sustainable strategy that "fulfills current needs without sacrificing those of future generations";
- enhance the living standard for its people;
- Enhance the health, welfare, physical safety, and educational status of its population.
- Establish standardized regulatory, compliance, and governance frameworks that are efficient and well-balanced, with suitable and fair procedures and regulations.

- Enhance the capacity to avoid and respond to natural and man-made catastrophes, particularly the capacity to deal with the effects of climate change; and

- Streamline infrastructure-based service industries, like water, utilities (energy), transportation (mobility), manufacturing, and telecommunications;

6.3. DERIVED DEFINITION

The following definition has been derived from the above-mentioned study and analysis:

> *An innovative city is known as a "smart city" if it adopts ICTs ("information and communication technologies") including innovative methods to enhance wellbeing, the effectiveness of urban services and environment, while simultaneously fulfilling the social, environmental, and economic requirements of both the present as well as the future generations.*

As mentioned in the beginning, there exist numerous definitions of smart city. There is no one blueprint for defining a smart city, and so there is no single definition exists for it Sullivan et al. (2003). In reality, the word is being used in a variety of fields with no agreed-upon meanings Toolkit on Environmental Sustainability for the ICT Sector (n.d.).

To various individuals, it implies different things UN Documents Gathering a Body of Global Agreements (2023). As a result, Smart City definitions differ from cities to cities and country to country, as per its degree of development, desire to reform and change, resources, and ambitions. So this derived definition is such a definition which can be generalized for any smart city with basic fundamentals terms mentioned in it and can be adopted widely throughout the world.

7. CONCLUSION

This research sheds light on the defined terminology of a "smart city" including the fundamental elements that contribute to build a smart city.

- This research evaluated around 115 current descriptions of "smart cities" from different citations to discover general features which defines a smart city;

- Similarly, this research may serve as the foundation for defining what a "smart city" is globally (accepted worldwide) and then be used to create a framework for evaluating how well a city is performing;

- The major metrics and categories that must be considered for a smart city were also taken into account in this research;

- A comprehensive description of a smart city has finally been offered in a generalized way.

- Although this research only uses secondary sources of data, it might be very helpful to comprehend the notion of a smart city; and

- Additionally, 30 important terms that should be part of a standard definition were identified and used.

CONFLICT OF INTERESTS

None.

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