Smart Cities in comparison: An analysis of the best Smart Cities.

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Abstract

This research paper aims to identify the best Smart City in the world, by investigating the rankings of Smart Cities, based on its main characteristics and implemented policies. The purpose of this study is to provide a comprehensive understanding of what makes a city "Smart" and to highlight the successful strategies employed by the top-ranked Smart Cities. The research employs a qualitative analysis approach, utilizing thematic maps created with the QGIS software. This methodology allows for a detailed examination of various factors contributing to a Smart City's status, including but not limited to, technological integration, sustainable practices, and citizen participation. The expected results of this study is to report and analyze the best smart cities, according to the Smart City rankings, and also to shed light on the key elements and policies that contribute to their success. These findings could serve as a benchmark for other cities striving to achieve 'Smart' status. Furthermore, the thematic maps will visually represent the distribution and implementation of Smart policies, providing a clear and comprehensive overview of the Smart landscape in the top-ranked cities. This research has the potential to contribute to the field of urban development and planning, particularly in the context of Smart Cities. It could guide policymakers and city planners in designing and implementing effective strategies to transform their cities into more sustainable, efficient, and livable spaces.

Keywords: Smart City, Smart City Rankings, Urban development, Urban planning, QGIS.

1.Introduction

1.1 Background (Smart City)

The concept of a Smart City has gained significant attention in recent years, with advancements in technology and a growing emphasis on sustainable urban development [1]. A Smart City is often associated with the integration of technology into urban infrastructure to enhance the quality of life, efficiency of urban operations, and competitiveness [2]. However, the concept extends beyond mere technological integration. It encompasses sustainable practices, citizen participation, and a host of other factors that contribute to a city's smart status [1].

Technological integration in a Smart City involves the use of Information and Communication Technology (ICT) and other innovative technologies to manage the city's assets [3]. These assets include public information systems, schools, libraries, transportation systems, hospitals, power plants, water supply networks, waste management, law enforcement, and other community services. The aim is to improve the quality of services, reduce costs, optimize resource consumption, and enhance interaction between citizens and the government [3]. Sustainable practices in a Smart City involve the implementation of strategies aimed at improving environmental sustainability [4]. This includes the promotion of renewable energy sources, waste management, water conservation, and sustainable urban planning [4]. The goal is to create a city that is not only technologically advanced but also environmentally friendly [4]. Citizen participation is another crucial aspect of a Smart City [5]. It involves the active involvement of citizens in decision-making processes, thereby promoting transparency and accountability [5]. This

can be facilitated through e-governance, where ICT is used to provide government services, exchange information, communicate with citizens, and facilitate various transactions [5]. The impact of Smart Cities on urban life is profound. They offer a host of benefits, including improved quality of life, increased efficiency, reduced environmental impact, and enhanced citizen participation [6]. However, they also pose challenges, such as privacy concerns and the digital divide, which need to be addressed to fully realize their potential [7].

Smart Cities represent a revolutionary approach to urban development and planning. They integrate technology, promote sustainability, and encourage citizen participation to create a more efficient, livable, and sustainable urban environment [8]. However, it is crucial to address the associated challenges to ensure that the benefits of Smart Cities are realized for all citizens [7]. Looking ahead, the future of Smart Cities appears promising, with advancements in technology and a growing emphasis on sustainability and citizen participation shaping the urban landscapes of tomorrow [9].

1.2 Purpose and research questions
The purpose of this study is to provide a comprehensive understanding of what makes a city "Smart" and to highlight the successful strategies employed by the top-ranked Smart Cities. This research aims to solve urban problems and improve citizens' quality of life through the fourth industrial revolution technology and governance between stakeholders. It seeks to improve convenience, increase efficiency, preserve energy, improve water quality and air quality, detect and solve problems quickly, recover from disasters, collect data for better decision making, use effective resources, and share data across regions.
The research within this article is structured on the basis of the following research question: what are the similarities and differences in the topic areas that can be identified in smart city research around the world, and what are the implications of such similarities and differences for the research and practice of smart cities around the world and therefore, what is the best Smart City in the world?

2. Literature Review
2.1 The Smart Cities
A smart city is a concept that integrates information and communication technology (ICT), and various physical devices connected to the IoT network to optimize the efficiency of city operations and services and connect to citizens [10]. Determining if a city is smart involves understanding the key components that make up a smart city and how these components interact to provide efficient and effective services to its residents.

2.1.2 Integration of Building Information Modeling (BIM) and Geographic Information System (GIS)
One of the key components of a smart city is the integration of Building Information Modeling (BIM) and Geographic Information System (GIS). BIM is a digital representation of physical and functional characteristics of a facility, while GIS is a system designed to capture, store, manipulate, analyze, manage, and present spatial or geographic data [11]. The integration of BIM and GIS can help in the development of a Smart City by

providing a comprehensive view of the city's infrastructure and enabling efficient planning and management [12].

2.1.3 Smart Buildings

Smart buildings are another crucial component of a smart city. These buildings use automation to control the building's operations, including heating, ventilation, air conditioning, lighting, security, and other systems. A smart building integrated into a smart city (SBISC) can contribute to the energy efficiency of the city and improve the quality of life for its residents [13]. In the context of contemporary urban development, smart buildings, defined by their incorporation of diverse mechanical and electrical elements to optimize the design and functionality of Heating, Ventilation, and Air Conditioning (HVAC) systems, represent a crucial component in the pursuit of energy efficiency. [14]. These buildings utilize advanced digital technologies, information science, and sustainable technologies for construction, maintenance, and management [15]. The concept of smart buildings involves controlling electric loads adaptively, switching off unused equipment to reduce total energy consumption [16].

Smart buildings are equipped with different sensing and actuation technologies, allowing dynamic control of systems based on their requirements (ibidem). Sensing technologies installed inside and outside the building can monitor parameters such as temperature, smoke, humidity, and motion in real-time (ibidem).

Moreover, smart buildings play a crucial role in demand response, contributing to environmental and economic benefits. They enable buildings to participate as distributed energy resources, supporting the increased use of variable renewable electricity sources [17].

In the context of smart cities, smart buildings form an integral part of the infrastructure, contributing to efficient energy management, improved mobility, safety, and environmental protection and pivotal in the transition towards sustainable smart grids [18].

2.2 Determining a Smart City

Determining if a city is smart involves evaluating the presence and effectiveness of these key components. A city that effectively integrates BIM and GIS, has smart buildings, and uses ICT and IoT to optimize city operations and services can be determined as a smart city [19]; [20].

A smart city is more than just a city that uses technology. It is a city that uses technology to improve the quality of life for its residents and to optimize city operations and services. By understanding the key components of a smart city and how they interact, we can determine if a city is smart and work towards creating smarter cities for the future.

Smart buildings, characterized by the integration of various mechanical and electrical components, are a significant aspect of modern urban development [21]. These buildings enhance the design and operation of Heating, Ventilation, and Air Conditioning (HVAC) systems, thereby achieving energy efficiency [22]. The advancements in HVAC system

control have two significant trends: to improve the robustness of control and to improve the efficiency of system-level real-time optimization [23]. In the context of urban development, energy efficiency policies and demand-side management programs play a crucial role [24]. Towards sustainable smart cities: A review of trends, architectures, components, and open challenges in smart cities. Sustainable cities and society, 38, 697-713. [25].

3. Methods

The methodology for this research paper is designed to provide a comprehensive understanding of what makes a city "Smart" and to highlight the successful strategies employed by the top-ranked Smart Cities. The research employs a qualitative analysis approach, utilizing thematic maps created with the QGIS software.

The first step in the methodology involves data collection. This is done by investigating the rankings of Smart Cities, based on their main characteristics and implemented policies. The data is collected from various top journals and databases using the keywords 'smart city'. The selected papers include those published in the SSCI-class sustainability, Sustainable Cities and Social Studies journals, and the SCI-class IEEE.

The next step involves a qualitative analysis of the collected data. This analysis allows for a detailed examination of various factors contributing to a Smart City's status, including but not limited to, technological integration, sustainable practices, and citizen participation. The qualitative analysis is conducted using a systematic literature review.

The research employs thematic maps created with the QGIS software. These maps visually represent the distribution and implementation of Smart policies, providing a clear and comprehensive overview of the Smart landscape in the top-ranked cities.

The final step involves analyzing and reporting the best smart cities, according to the Smart City rankings. The key elements and policies that contribute to their success are highlighted. These findings could serve as a benchmark for other cities striving to achieve 'Smart' status.

4. Findings

4.1 The "Smart City Index"

One of the most authoritative rankings analyzing Smart Cities is the "IMD Smart City Index" that focuses on how citizens perceive the scope and impact of efforts to make their cities 'smart' [26]. It is implemented by the Institute for Management Development (IMD) in collaboration with the Singapore University for Technology and Design (SUTD) (ibidem).

Since 2019, the IMD has produced a Smart City Index offering a balanced focus on economic and technological aspects of smart cities on the one hand, and "humane dimensions" of smart cities (quality of life, environment, inclusiveness) on the other [27]. The initial effort to produce what should become an internationally recognized global smart city index consists of two distinct phases and deliverables.

First, a set of case studies of smart cities at different stages of development, providing a diverse international basis of experience, with the purpose of enhancing the realism and pertinence of the model underpinning the index to be proposed [28]. Second, the first iteration of the index methodology was defined, leading to a global ranking of smart cities along that index in 2019 (ibidem).

Being a globally-recognized 'smart' city is now critical for attracting investment and talent, creating a potential 'virtuous cycle' in favor of an advanced group of cities such as Singapore, Zurich, and Oslo. The competitiveness analysis demonstrates the areas in which a city lacks development and which areas could be improved to match the benchmark standards of smart cities [29].

The first ranking on Smart Cities that the IMD university published was on 2019. The research was carried out by city experts and university professors from all over the world. Various evaluations and studies were carried out on all the cities analyzed, also taking into account the different points of view of the citizens of these cities.

The revamped 2023 edition of the IMD Smart City Index (SCI) has seen Asian and European economies dominate the top 20 [30].

Being a globally-recognized 'smart' city is now critical for attracting investment and talent, creating a potential 'virtuous cycle' in favor of an advanced group of cities such as Singapore, Zurich, and Oslo [31]. The competitiveness analysis demonstrates the areas in which a city lacks development and which areas could be improved to match the benchmark standards of smart cities.

The Index looked into city living in 141 cities, casting its net much wider than in 2021 when the total was 118. In 2023, some 20,000 citizens were surveyed about living in their cities; they were asked which were the most urgent priorities, from affordable housing and road congestion to fulfilling employment and green spaces [32].

The Index, produced by The Smart City Observatory, part of the IMD World Competitiveness Center, differs from others by being citizen-centric. It combines hard data and survey responses to show the extent to which technology is enabling cities to address the challenges they face to achieve a higher quality of life for their inhabitants [33].

The IMD Smart City Index 2023 provides valuable insights into the cities at the forefront of this transformation [34].

According to the IMD, the competitiveness that is generated between the various cities, through rankings of this type, leads to significant developments in the management and commitment to the progress of each city [29] [35].

This ranking, constructed through a comprehensive analysis of individual cities' basic information such as life expectancy at birth and average years of schooling, quality of life

from health and safety perspectives, presence of digital systems for public services and urban greenery, and quality of work, education, and governance with an emphasis on digital platform accessibility, assigns each city a score from 0 to 100, culminating in a total score ranging from AAA to D, based on the city's performance relative to others. (ibidem).

Table 2.1 Top 10 Smart Cities - IMD Smart City Index.

Ranking	2023	2021	2020	2019
1	Zurich	Zurich	Zurich	Zurich
2	Oslo	Oslo	Oslo	Oslo
3	Canberra	London	Copenhagen	London
4	Copenhagen	Lausanne	Prague	Geneva
5	Lausanne	Copenhagen	Helsinki	Copenhagen
6	London	Geneva	Hamburg	Helsinki
7	Singapore	Singapore	Singapore	Geneva
8	Helsinki	Hamburg	Geneva	Prague
9	Geneva	Helsinki	Stockholm	Stockholm
10	Stockholm	Prague	London	Singapore

Source: Own processing on IMD Smart City Index data.

In all four rankings published by the Institute for Management Development (IMD), only Zurich and Oslo have consistently maintained their first and second positions, respectively.

Zurich topped the IMD Smart City Index 2023 (2021, 2020 and 2019 as well), making it the smartest city globally [36]. The city has consistently topped the index for four consecutive times. The ranking uses diverse criteria to measure how smart a city is according to its citizens [37].

Oslo secured the second position in the IMD Smart City Index 2023 (and in the previous edition as well) [36].

Canberra ranked third in the IMD Smart City Index 2023. The city's tech-forward mindset has helped improve citizens' quality of life [38].

It should be noted that the rankings are predicated on the extent to which cities leverage technology to surmount the challenges they encounter in their quest to enhance the quality of life for their inhabitants.

4.2 "IESE Cities in Motion Index"
The IESE Cities in Motion Index is a comprehensive index developed by the IESE Business School that measures the sustainability of key global cities and the quality of life of their inhabitants [39]. The index aims to provide a holistic view of cities by covering different key dimensions.

The index analyses 101 indicators across 9 key dimensions: Human capital, Social cohesion, Economy, Governance, Environment, Mobility and transportation, Urban planning, International projection, Technology [40].

These dimensions reflect both objective and subjective data to offer a comprehensive view of each city. The index is a useful tool for cities to understand their strengths and weaknesses in order to develop a smart strategy (ibidem).

The initiative connects a worldwide network of city experts and specialized private companies with local administrations all over the world, with the goal of developing valuable ideas and innovative tools that can generate smarter cities and promote change at the local level [41].

The 2019 edition of this ranking marks was the 6th iteration of this ranking, and its predecessors have been utilized as benchmarks to compare the performance of smart cities worldwide in recent years.

In an effort to enhance the structure and coverage of the ranking, this edition aimed to provide a comprehensive global index. A total of 174 cities spanning 80 countries were analyzed, making it the most geographically extensive ranking to date.

The ranking of 2019 incorporates a total of 96 indicators (less than the ranking of 2022) that provide an all-encompassing perspective of each city [40].

In th 2019 edition of the Smart City ranking, London emerged as the smartest city in the world, followed by New York City. Singapore, which held the top spot in the Smart City Index, now ranks seventh; Oslo, previously third, has dropped to the fourteenth position in this ranking by the University of Navarra (ibidem). On a continental scale, Europe houses the highest proportion of Smart Cities, accounting for 33% of the total; North America and Asia trail behind with only 12% and 14% respectively, despite cities from these continents occupying the top spots in the rankings of individual dimensions (ibidem).

This ranking is considerably more detailed than its predecessor and covers a wider range of indicators. However, as acknowledged by the University of Navarra, gathering all the data for this analysis was a challenging task. Consequently, efforts are being made to engage as many cities as possible to obtain their information, with the aim of further enhancing the forthcoming seventh edition of this global Smart Cities ranking.

Table 4.2 Top 10 Smart Cities - IESE Cities in Motion Index.

Ranking	2022	2020	2019	2018
1	London	London	London	New York
2	New York	New York	New York	London
3	Paris	Paris	Amsterdam	Paris
4	Tokyo	Tokyo	Paris	Tokyo
5	Berlin	Reykjavík	Reykjavík	Reykjavik
6	Washington	Copenhagen	Tokyo	Singapore
7	Singapore	Berlin	Singapore	Seoul
8	Amsterdam	Amsterdam	Copenhagen	Toronto
9	Oslo	Singapore	Berlin	Hong Kong
10	Copenhagen	Hong Kong	Vienna	Amsterdam

Source: Own processing on IESE Cities in Motion Index data.

4.3 The "Top 50 Smart Cities Governments"

Another ranking that is worth mentioning is the "Top 50 Smart Cities Governments" by the Eden Strategy Institute, a consulting firm specializing in Smart City innovation and support for governments [42]. This ranking shows the fifty best Smart Cities under just one of the six characteristics of Smart Cities, governance [43].

The Eden Strategy Institute analyzed one hundred and forty cities that emerged from various articles and websites that talk about Smart Cities, including the 2017 Smart Cities Index, the Cities in motion, Juniper Research's Smart Cities Ranking and the Smart Cities Perspectives of Procedia. Computer Science.

In the face of the high experience of consulting to government agencies and the design of urban planning solutions, the Eden Strategy Institute was able to identify three areas in which smart cities can develop, i.e. the field of application of Smart strategies in city development plans. , the coverage of the geographical area that the Smart projects involve and the integration of these projects.

Whether the development of Smart projects focuses on a wide range of urban services or on a few projects, a city's Smart plan focuses on sustainability, and leveraging technology to reduce waste and energy consumption. It is important to calculate the size of Smart projects by geographical coverage and also by number of citizens involved [44].

According to ranking of 2019, the smartest city in the world is London, second Singapore, third Seoul. Oslo is not among the top fifty Smart Cities according to the Eden Strategy Institute [45].

Top 50 Smart City Governments identifies a suite of 10 key tools that mayors have found effective in developing smart cities [46]. It provides detailed reflections on how these tools were applied differently to achieve a range of outcomes and highlights the achievements of 50 leading governments that have steered their smart cities forward [47].

In the 2021 edition of the rankings, significant changes were attributed to each city's management of COVID-19, as well as their resilience, adaptability, foresight, and proactiveness in anticipating and addressing key urban challenges [48]. The full report includes detailed feature articles covering topics such as COVID-19, sustainability, data privacy, financing, and social inclusion (ibidem).

The top spots in the 2021 Smart City Government rankings were earned by Singapore, Seoul, London, Barcelona, and Helsinki (ibidem). These cities have demonstrated exceptional leadership and innovation in using smart technologies to improve the lives of their citizens (ibidem).

Table 4.3 Top 10 Smart Cities of the ranking "Top 50 Smart Cities Governments".

Ranking	2021	2019
1	Singapore	Singapore
2	Seoul	Seoul

3	London	London
4	Barcelona	Barcelona
5	Helsinki	Helsinki
6	New York City	New York City
7	Montreal	Montreal
8	Shanghai	Shanghai
9	Vienna	Vienna
10	Amsterdam	Amsterdam

Source: Own processing on Top 50 Smart Cities Governments data.

4.4 Cartographic representation

In the respective rankings, the cities that have achieved the premier position are Singapore, London, and Zurich. The cities that have been accorded the second and third positions are Seoul, New York, and Paris, followed by Oslo and Canberra. These leading Smart Cities, occupying the first, second, and third positions, have been incorporated in the map presented in Figure 1.

a

Fig. 1. (a) The 25 best Smart Cities, according to Smart City Index
Source: own production on qgis data, smart city Index.

The geographical distribution of these cities, as depicted in Figure 1, provides a global perspective on the development of Smart Cities. It is noteworthy that these leading Smart Cities are spread across different continents, reflecting the global reach and impact of the Smart City concept.

The map serves as a visual guide to understanding the spatial distribution of Smart Cities and offers insights into the global trends in urban development and planning. It underscores the fact that the pursuit of becoming a 'Smart City' is a global phenomenon, transcending geographical boundaries.

It is also imperative to consider that there are diverse conceptions of Smart Cities around the world, as demonstrated in various research as evidenced by the contrasting perceptions of Smart City between Italy and Norway [49]. This is reflected in the vision of a city that is green and sustainable on one hand [50], and on the other hand, a population that demands the presence and use of Smart devices in every circumstance [51]. Additionally, various Smart Services offered by the public sector, such as Smart Touristic Ports [52], may be taken into account, although not all Smart Cities have implemented these services.

5. Discussion

The findings of this research provide a comprehensive understanding of the concept of a Smart City and the key elements that contribute to its status. The study identifies the best Smart Cities in the world, based on rankings, and highlights the successful strategies they have employed.

The integration of technology into urban infrastructure is a significant aspect of a Smart City. This involves the use of Information and Communication Technology (ICT) and other innovative technologies to manage the city's assets, including public information systems, schools, libraries, transportation systems, hospitals, power plants, water supply networks, waste management, law enforcement, and other community services. The aim of technological integration is to improve the quality of services, reduce costs, optimize resource consumption, and enhance interaction between citizens and the government.

Within the context of the Smart Environment, it is imperative to address the frequently underexplored subject of social media platforms, which have emerged as a significant medium for information dissemination [53]. The concept of a Smart City extends beyond mere technological integration. It also encompasses sustainable practices and citizen participation. Sustainable practices involve the implementation of strategies aimed at improving environmental sustainability, including the promotion of renewable energy sources, waste management, water conservation, and sustainable urban planning. The goal is to create a city that is not only technologically advanced but also environmentally friendly.

Citizen participation is another crucial aspect of a Smart City. It involves the active involvement of citizens in decision-making processes, thereby promoting transparency and accountability. This can be facilitated through e-governance, where ICT is used to provide government services, exchange information, communicate with citizens, and facilitate various transactions.

The impact of Smart Cities on urban life is profound. They offer a host of benefits, including improved quality of life, increased efficiency, reduced environmental impact, and enhanced citizen participation. However, they also pose challenges, such as privacy concerns and the digital divide, which need to be addressed to fully realize their potential.

The IMD Smart City Index and the IESE Cities in Motion Index provide valuable insights into the cities at the forefront of this transformation. According to these indices, cities like Singapore, Zurich, and Oslo have consistently ranked high, demonstrating their effective

use of smart technologies and strategies. These cities serve as benchmarks for other cities striving to achieve 'Smart' status.

In the face of the COVID-19 pandemic, the resilience, adaptability, foresight, and proactiveness of these cities in managing the crisis have further underscored their 'Smart' status. Their effective management of the crisis, as well as their continued focus on enhancing the quality of life for their citizens, exemplifies the true essence of a Smart City.

This research contributes to the field of urban development and planning, particularly in the context of Smart Cities. It provides a roadmap for policymakers and city planners in designing and implementing effective strategies to transform their cities into more sustainable, efficient, and livable spaces. The findings of this research underscore the importance of a holistic approach in developing Smart Cities, one that goes beyond technological integration and encompasses sustainable practices and citizen participation.

The concept of a Smart City is multifaceted, encompassing technological integration, sustainable practices, and citizen participation. The best Smart Cities, as identified by this research, excel in all these aspects, providing a high quality of life for their citizens, and serving as a model for other cities around the world. As cities continue to evolve and face new challenges, the concept of a Smart City will continue to be refined and redefined. However, the core principles of improving the quality of life for citizens, enhancing efficiency, and promoting sustainability will remain central to the concept of a Smart City.

6. Conclusion

This article has provided a research of the concept of a Smart City and has underscored the multifaceted nature of a Smart City, encompassing technological integration, sustainable practices, and citizen participation. The best Smart Cities, as identified by this research, excel in all these aspects, providing a high quality of life for their citizens, and serving as a model for other cities around the world.

However, as cities continue to evolve and face new challenges, the concept of a Smart City will continue to be refined and redefined. The core principles of improving the quality of life for citizens, enhancing efficiency, and promoting sustainability will remain central to the concept of a Smart City. The findings of this research underscore the importance of a holistic approach in developing Smart Cities, one that goes beyond technological integration and encompasses sustainable practices and citizen participation.

Looking ahead, the research agenda should focus on several key areas. First, future studies could delve deeper into the challenges faced by Smart Cities, such as privacy concerns and the digital divide, and explore strategies to address these issues. Research could also examine the role of emerging technologies, such as artificial intelligence and blockchain, in shaping the future of Smart Cities. There is also a need for more comparative studies that analyze the performance of Smart Cities across different regions and contexts. Such studies could provide valuable insights into the factors that contribute to the success of Smart Cities in different parts of the world.

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