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Smart Cities in the Global Context: Geographical Analyses of Regional Differentiations

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Abstract: The increasing urbanisation and technological advancements have driven the global adoption of smart city initiatives, yet regional differences persist due to economic, social, and technological disparities. Despite the numerous studies on smart cities, there remains a research gap in comprehensive global analyses exploring regional differentiations in smart city development. This study aims to examine how smart cities differentiate, especially through associations between regions and smart city dimensions. This study utilises data from the IMD Smart City Index 2023 and applies a multi-step methodology based on the United Nations' geographic regions, employing geographical and statistical analyses. The findings reveal distinct regional differentiations, highlighting a clear Global North–South divide and notable subregional differentiations, including the North–South divide in the Americas and the East–West divide in Asia. The correlation analysis demonstrates significant relationships between smart city dimensions, with smart mobility and smart living exhibiting the highest association. The correspondence analysis further identifies four major regional concentration groups, notably the Global North, with equi-distant associations with all dimensions, and Asia, which is closely linked to smart governance. The findings confirm that smart city development is not uniform and is shaped by regional socio-economic and technological conditions and emphasises the need for context-dependent regional policies.

Keywords: smart cities; regional differentiations; smart city dimensions; IMD Smart City Index 2023

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1. Introduction

The world has become increasingly urbanised, with over 55% of the global population residing in urban areas as of 2018, up from 30% in 1950. This trend is expected to continue, with projections indicating that by 2050, 68% of the population will live in urban areas [1]. This urban growth has presented opportunities but also new challenges, necessitating innovative solutions for sustainable urban management. In response to these challenges, the smart city concept has emerged as a strategic approach to enhancing urban efficiency through technological and data-driven solutions [2–4]. By leveraging digital innovations, smart cities aim to improve infrastructure, governance, mobility, and sustainability, making urban environments more liveable and resilient.

The smart city concept has been widely debated in the academic and policy discourse [5–10]. Despite having no universally accepted definition, there is a consensus around its central theme—technology as the catalyst for the smart city. Early interpretations

emphasise a technology-driven approach, viewing smart cities as urban spaces optimised through information and communication technology (ICT), artificial intelligence, and big data analytics [11–19]. However, recent perspectives endorse a human-centred approach, integrating socio-economic factors, governance, and environmental issues to enhance urban life and sustainability [20–26]. This diversity in approaches illustrates the dynamic and interdisciplinary nature of the smart city concept, which ranges from a purely technological framework to a more comprehensive perspective encompassing society, economy, and the environment, along with technology. This study adopts the comprehensive perspective, defining smart cities as urban environments that integrate advanced technologies while addressing regional development patterns, governance structures, and socio-economic conditions. This comprehensive perspective of the definition of smart cities indicates that smart city development is not solely reliant on the availability of the technological infrastructure but is also shaped by the institutional, social, and economic infrastructures [27,28], as well as the availability and quality of human and social capital [29–31].

Cities are complex systems, necessitating the consideration of various dimensions to achieve smart outcomes [32,33]. Researchers and institutions employ different dimensions to articulate their perspectives regarding the goals of the research or the smart city initiative [6,34–36]. An examination of the smart city literature reveals that the most frequently mentioned smart city dimensions are people, governance, economy, living, the environment, and mobility [22,30,37,38]. Nonetheless, there is also research focusing on specific dimensions, such as healthcare and education systems, security and safety, energy and waste management, or public participation [6,15,27,33,39]. This study adopts the dimensions developed by Giffinger and his colleagues [22] in the most-cited reference on smart city research, while the other dimensions are considered under the following main categories: smart contract, smart transaction, and smart agriculture are located under smart economy; participation is located under smart governance; smart health, smart education, and smart safety/security are located under smart living; and finally, smart energy and smart waste management subjects are located under the smart environment dimension.

Smart people are educated, technologically skilled, and socially active individuals who drive innovation, public participation, and economic growth [40,41]. Smart governance ensures transparency, efficiency, and citizen participation in decision-making processes through digital tools and adaptive policies [42,43]. Smart economy leverages technological advancements, including blockchain systems and online transactions, integrated national/international markets, and smart agriculture implementations, in order to enhance the economic competitiveness, productivity, entrepreneurship, trademarks, and flexibility of the labour market [22]. Smart living utilises emerging technologies to improve overall quality of life, including different aspects, such as housing, healthcare, education, tourism, and security services [22]. The smart environment integrates technology into traditional systems to optimise resource management and energy efficiency to achieve environmental sustainability [40], while smart mobility employs technology to enhance the local and international accessibility and connectivity of people through ICT infrastructure and sustainable urban transportation systems [27]. Together, these dimensions define a smart city's ability to foster innovation, efficiency, and sustainability. Not all dimensions need to be observable or concurrently present in a specific city for it to be qualified as a smart city [33]. Based on the areas of interest, the smart city dimensions may vary from one city to another [27]; some may be more prominent, while others are less referenced or even omitted.

The rapid evolution of the smart city concept has led to significant regional differentiations in smart city implementations due to economic, social, and technological disparities. While numerous studies have attempted to assess, evaluate, and compare smart cities at

different scales [44–59], there are few comprehensive studies addressing regional differentiations in the global context in the smart city literature.

A significant study focusing on regional differentiation was conducted by Alizadeh [56], who examined the Global North–South divide in smart city development, highlighting how Global South cities often adopt Northern models without questioning their contextual conditions. Analysing IBM's Smarter Cities Challenge, this study reveals differing priorities: economic growth and sustainability in the Global North versus administrative efficiency in the Global South. To conclude, it calls for context-dependent smart city frameworks to address governance and equity challenges. However, it struggles to fully explain regional differentiations, primarily highlighting the Global North–South divide but not different regional scales. Another study conducting a geographical analysis of smart cities, directed by Carboni [57], analyses the world's top-ranked smart cities, identifying key characteristics and policies that contribute to their success. Using qualitative analysis and thematic mapping, it compares the top-ranked smart cities from the IMD Smart City Index, IESE Cities in Motion Index, and Top 50 Smart Cities Governments Index. To conclude, it underscores the global distribution of smart cities across various continents, emphasising the international impact and importance of the smart city concept. However, it overlooks regional differentiations by only focusing on the top-ranked smart cities, lacking an in-depth analysis of the dimensions that shape smart city development across different regional contexts. A distinct study focusing on a global review of smart cities was conducted by Chen [58], which explores the relationship between smart cities, subjective well-being, and urban liveability, contending that happiness is essential for fostering sustainable urban growth. It concludes that technological advancements alone do not provide enhanced quality of life; rather, elements such as green areas, air pollution management, and recycling services substantially influence urban well-being. The distinguishing feature of the study is that it underscores regional disparities, indicating that cities within varying geographies encounter distinct challenges in attaining sustainability and happiness. One limitation of this study is that it approaches smart city development primarily from the perspectives of sustainability, liveability, and urban happiness, so the analyses made use of the smart cities as a tool, rather than an end goal, in response to the research questions and areas of concentration. The last study examined was carried out by Kuzior and colleagues [59], who explored the e-governance performance of 68 cities listed in the IMD Smart City Index by considering economic, social, political, and technological indicators. Utilising statistical analyses, the research reveals that the Human Development Index (HDI) strongly influences e-governance, while Gross National Income (GNI) per capita has no direct impact. The research underscores the role of digital infrastructure and citizen engagement in smart governance, offering valuable insights for policymakers. By focusing only on one dimension of the smart city, it faces limitations in its ability to explain all aspects of the smart city concept and its dimensional diversity in the global context.

A review of the research regarding the differentiations of smart cities at different scales (Table A1) shows specific shortcomings arising from (1) the broader perspective that either encompasses global regions [56] or scrutinises particular cities worldwide [51,52,57,58]; (2) the narrow emphasis on specific cities [45,55], countries [47–49,54] or regions [44,46,50,53]; and (3) the limited focus on particular dimensions [59]. These shortcomings generate a research gap in the global evaluation of smart cities. The objective of this study is to conduct a comprehensive analysis of smart cities to address the identified research gap, with a particular emphasis on regional differentiations and the concurrent examination of smart city dimensions. The study explicitly addresses the following research questions:

1. How do smart cities differentiate across regions?

2. How do smart city dimensions relate to each other?
3. Which associations exist among smart city dimensions and regions?
4. Which factors contribute to the regional differentiations of smart cities?

In order to answer these research questions, the study conducts geographical and statistical analyses based on the data derived from the IMD Smart City Index 2023 [60] and explores differentiations at the sub/intermediary regional scale by the United Nations Department of Economic and Social Affairs, Statistics Division (UNSD) [61]. The main goal of this study is to deliver a comprehensive geographical analysis of smart cities, providing novel insights into regional differentiations within a global framework, in contrast to prior research, which predominantly concentrated on certain cities, countries, or regions. The findings of the research have significant policy implications, emphasising the need for context-dependent strategies considering the economic, social, and technological conditions of each region.

2. Materials and Methods

A multi-step research strategy was employed to fulfil the study's objective and to answer the research questions, encompassing (1) the identification of an appropriate data source, (2) methodical data extraction and aggregation, and (3) statistical data analyses. As illustrated in the methodology flowchart (Figure 1), the research began with the selection of the data source as the IMD Smart City Index 2023, followed by a two-stage data extraction process from records at the city scale. Relevant indicators were then grouped into six smart city dimensions, and average scores were calculated for each city and sub/intermediary region. Descriptive statistics and correlation and correspondence analyses were then applied to explore the differentiations between and associations among regions and smart city dimensions. Visualisation tools facilitated both statistical and geographic representations of the findings.

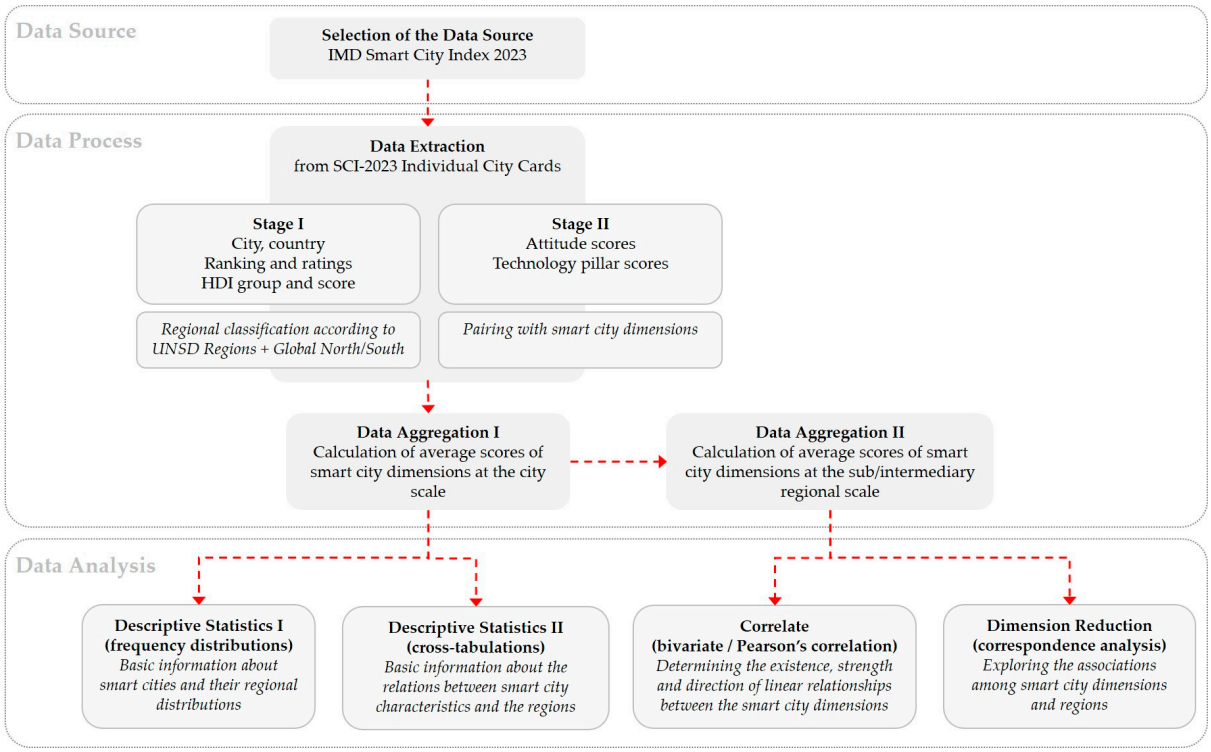


Figure 1. Methodology flowchart illustrating the multi-step research strategy used to explore the regional differentiations of smart cities based on the IMD Smart City Index 2023.

2.1. Data Source: IMD Smart City Index 2023

The research was conducted utilising the data from the chosen smart city index. The smart city indices are commonly utilised to assess and compare cities based on their smart city performances through quantitative indicators [42]. Various researchers and organisations have generated smart city indexing systems [22,30,60,62–66]. These indices vary in theme, scope, and measurement level, employing unique evaluation criteria and methods [3,57,67–72]; nonetheless, whether market-orientated or research-based, they all seek to assess cities based on their smartness level and to publish rankings accordingly. Despite criticisms regarding their comprehensiveness, flexibility, accountability, accuracy, and universality [3,67,68,71,72], these indices are useful in monitoring smart city performances and facilitating comparisons at different scales [73].

Based on the research conducted by Lai and Cole [68] aiming to critically examine different indices, the IMD Smart City Index (SCI), as "...an ongoing initiative... since 2019, has emerged as a pivotal tool within the domain of smart city assessment" [74] (p. 1332). This study selected the SCI as the data source for the following reasons: (1) it encompasses a broad range of cities, enabling a geographical analysis in the global context; (2) it evaluates technological, social, and economic dimensions, ensuring a holistic assessment [40]; (3) it assesses the dynamics of the city's ranking over time; (4) it is a reliable study, carried out over an extended period of time by a group of researchers and institutes; (5) it differs from other indices, being citizen-centric by relaying on data gathered through citizen surveys [74,75]; and (6) its data and/or method are frequently referenced in research examining smart cities [40,52,57–59,74,76,77] or as an index in research evaluating assessment tools [68,71,72].

The IMD Smart City Index 2023 (henceforth referred to as the SCI-2023) [60] is the fourth version of the research carried out by the International Institute for Management Development (IMD) in collaboration with the World Smart Sustainable Cities Organization (WeGO). The SCI-2023 assesses 141 cities globally through surveys that capture the perceptions of 120 randomly chosen citizens in each city of the smart city developments [78]. The survey comprises three sections aimed at (1) determining citizens' priorities for their cities, encompassing affordable housing, road congestion, employment opportunities, and green spaces; (2) evaluating their attitudes towards privacy concerns, specifically their comfort with technologies like facial recognition and the sharing of personal data to reduce congestion; and (3) understanding their perspectives on structure and technology pillars based on five specific domains: (a) health and safety, (b) mobility, (c) activities, (d) opportunities, and (e) governance [75]. The structure pillar evaluates issues pertaining to the city's existing infrastructure. It reflects how well the physical and institutional frameworks support the residents' quality of life, encompassing specific domains. The technology pillar assesses the availability and utilisation of technological solutions and services within the city. It examines how technology is integrated to enhance specific domains.

The SCI-2023 presents individual city cards, including basic information, survey results, and findings regarding the ranking and rating levels (Figure A1). Cities are categorised into four groups based on the Global Data Lab's Human Development Index (HDI) [79], which "... is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and having a decent standard of living" [80]. A rating scale (from AAA to D) is assigned within each HDI category based on the perception scores compared to group averages (Figure A2). Rankings are presented in two formats: (1) as a smart city ranking, from 1st to 141st in the SCI-2023, and (2) with a rating for each pillar and an overall smart city rating.

2.2. Data Process

This study compiled a structured database from individual city cards in the SCI-2023 for the data analysis. Cities listed in the SCI-2023 were coded with their respective countries and regions. Regions were classified according to the Standard Country or Area Codes for Statistical Use (M49) [61] by the UNSD "... based on continental regions; which are further subdivided into sub-regions and intermediary regions drawn as to obtain greater homogeneity in sizes of population, demographic circumstances and accuracy of demographic statistics" [61]. The scale for the analyses was determined to include the sub/intermediary regions (Figure 2). Additionally, regional classifications were refined to reflect the Global North–South divide based on the information from the United Nations Educational, Scientific and Cultural Organization (UNESCO), Organization for Women in Science for the Developing World [81]. Cities were also classified according to their populations. Population groups were obtained from the Size Class of Urban Agglomeration by the United Nations Human Settlements Programme (UN-Habitat) [82] and reclassified for the data analysis. Selected economic, social, and technological indicators of sub/intermediary regions were obtained from UNdata database [83] and the UNSD world statistics [84], enabling further discussions on the role of different factors in the regional differentiation of smart cities.

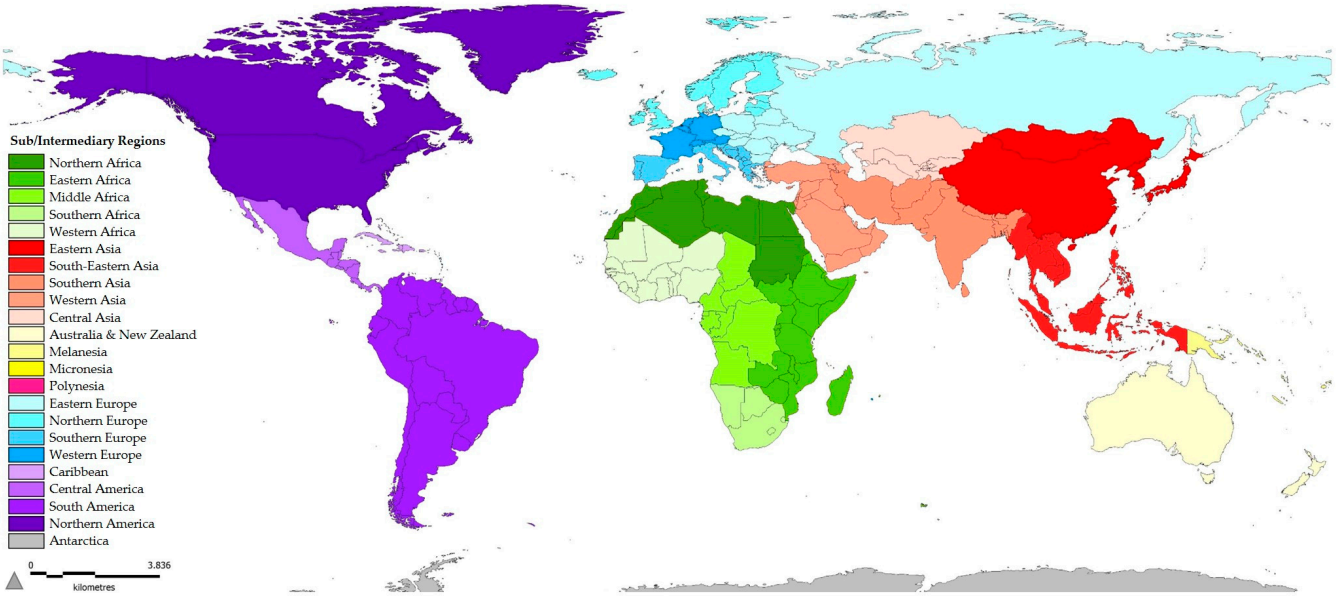
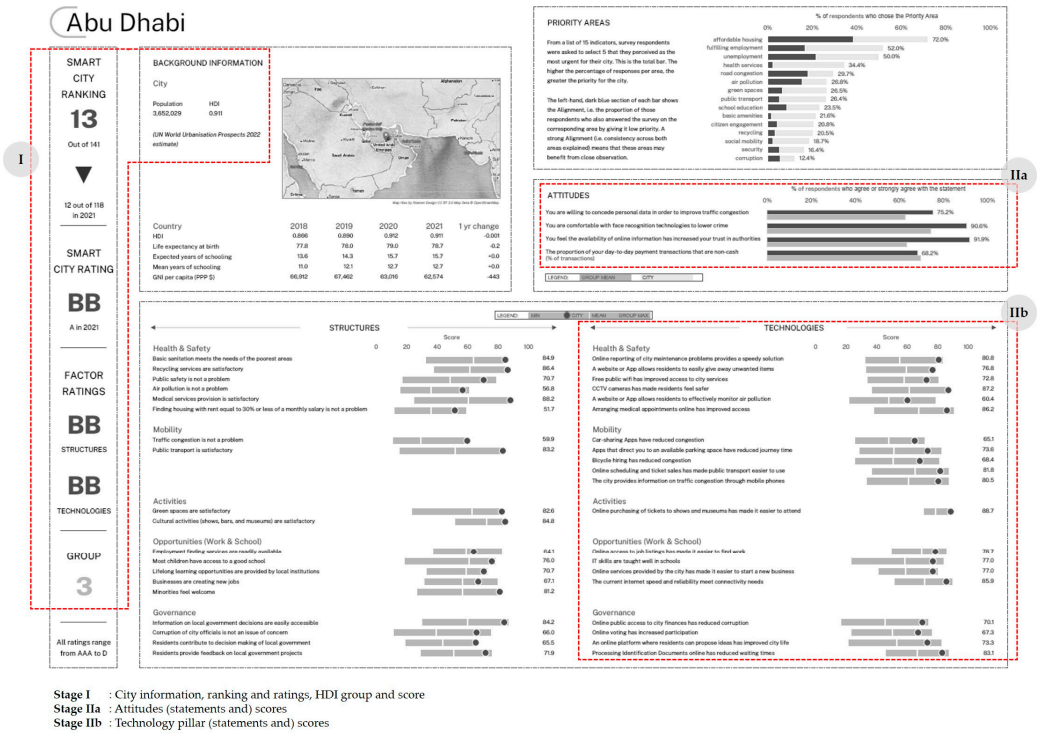


Figure 2. Sub/intermediary regions based on the Standard Country or Area Codes by UNSD [61].

Subsequent to the establishment of the basic database, primary data were extracted from SCI-2023 individual city cards in two stages (Figure 3). The smart city ranking, smart city and technology ratings, HDI group and score, and scores for the attitudes and technology pillar were encoded in the first stage. This study only included the scores for attitudes and the technology pillar, excluding the scores of the structure pillar, which measures the existing public service capacities. The reason of this exclusion was that the structure pillar does not directly relate to the implementation of the smart city and/or technological infrastructure. In the second stage, scores concerning the attitudes and the technology pillar were incorporated into the database to calculate the scores for the smart city dimensions. To accomplish this, attitudes and technology pillar statements from individual city cards were paired with six smart city dimensions (Table 1). The average of the accompanying scores was thereafter assigned as the score of the corresponding smart

city dimension. Ultimately, sub/intermediary regional smart city scores were derived by averaging the scores of cities within each region.



Stage I : City information, ranking and ratings, HDI group and score
Stage IIa : Attitudes (statements and) scores
Stage IIb : Technology pillar (statements and) scores

Figure 3. An example of an individual city card in the SCI-2023 [60] (p.36) and the sections referred to in the data extraction stages.

Table 1. Pairing the attitudes and technology pillar statements in the SCI-2023 with the smart city dimensions.

Pillar/Category and Domains in the SCI-2023 [60]	Statements in the SCI-2023 [60]	Smart City Dimensions					
		Smart People	Smart Governance	Smart Economy	Smart Living	Smart Environment	Smart Mobility
Attitudes	You are willing to concede personal data in order to improve traffic congestion	X					X
	You are comfortable with face recognition technologies to lower crime	X			X		
	You feel the availability of online information has increased your trust in authorities	X	X				
	The proportion of your day-to-day payment transactions that are non-cash	X		X			
Technology	Online reporting of city maintenance problems provides a speedy solution		X			X	
Health & Safety	A website or App allows residents to easily give away unwanted items	X	X			X	
	Free public wifi has improved access to city services		X				X
	CCTV cameras has made residents feel safer				X		X
	A website or App allows residents to effectively monitor air pollution				X	X	
	Arranging medical appointments online has improved access				X		

Table 1. *Cont.*

Pillar/Category and Domains in the SCI-2023 [60]		Statements in the SCI-2023 [60]	Smart City Dimensions					
			Smart People	Smart Governance	Smart Economy	Smart Living	Smart Environment	Smart Mobility
Technology	Mobility	Car-sharing Apps have reduced congestion						X
		Apps that direct you to an available parking space have reduced journey time						X
		Bicycle hiring has reduced congestion						X
		Online scheduling and ticket sales has made public transport easier to use						X
		The city provides information on traffic congestion through mobile phones						X
	Activities	Online purchasing of tickets to shows and museums has made it easier to attend			X	X		
	Opportunities (Work & School)	Online access to job listings has made it easier to find work			X			
		IT skills are taught well in schools	X			X		
		Online services provided by the city has made it easier to start a new business			X			
		The current internet speed and reliability meet connectivity needs						X
	Governance	Online public access to city finances has reduced corruption		X				
		Online voting has increased participation		X				
		An online platform where residents can propose ideas has improved city life		X				
		Processing Identification Documents online has reduced waiting times		X				

All statistical computations and visualisations were performed using SPSS version 11.0 statistical software, while MapInfo version 9.0 GIS (Geographical Information System) software was used to generate cartographic materials. These tools were selected due to their capacity to support both traditional statistical methods and visual geographic representation, enhancing the findings of the study.

2.3. Data Analysis

This study employs a structured analytical framework to explore the regional differentiations of smart cities. The data analysis was conducted in two stages: (1) using descriptive statistics to depict the general patterns and geographical distribution of cities listed in the SCI-2023, and (2) conducting statistical analyses to detect the relationships between smart city dimensions and the associations among sub/intermediary regions and smart city dimensions.

To address the first research question—How do smart cities differentiate across regions?—the study applied descriptive statistics, including frequency distributions and cross-tabulations, to examine the geographical distributions, population groups, HDI categories, technology, and smart city ratings. This method facilitated an initial understanding of the regional representation and differentiation patterns of smart cities.

To explore the second research question—How do smart city dimensions relate to each other?—a correlation analysis was conducted. Correlation analysis, in general, is a statistical method employed to ascertain the existence, direction, and strength of a relationship between two variables. The most commonly referenced correlation coefficients for measur-

ing relationships between two continuous variables are the Pearson correlation coefficient for linear relationships and Spearman's rho for non-linear relationships [85]. Since the database consists of index scores that approximate normal distribution (Figure A3) and also considering the linear relationships between smart city dimensions (Figure A4), this study refers to the Pearson correlation coefficient (r), which is a "...dimensionless measure of the covariance..." [86] (p. 1763), ranging from -1 to 1, where values close to ± 1 indicate strong positive/negative correlations while values near 0 suggest a weak or no linear relationship. The correlation coefficients between dimensions were computed by referring to the scores of smart city dimensions at the sub/intermediary regional scale. These sub/intermediary regional scores were calculated during the data aggregation process by taking the averages of smart city dimensions of all cities within that respected sub/intermediary region. This method provided a robust measure of the strength and direction of the relationships between smart city dimensions at the sub/intermediary regional scale.

To respond to the third research question—Which associations exist among smart city dimensions and regions?—and to further evaluate the results obtained by the correlation analysis, a correspondence analysis was employed. As a type of multivariate statistics, the correspondence analysis breaks down contingency tables into their constituent parts [87] to represent different levels of variation across the rows and columns [88]. It can be considered a mapping technique that concurrently visualises the associations between the rows and columns of cross-tabulations [89]. Graphical representations of cross-tabular data, namely correspondence maps, constitute a form of data description via visualisation. These maps facilitate the swift analysis of the associations embedded in the data, as the proximity of the points on these maps indicates strong associations [90–92]. Correspondence analysis offers several advantages as a statistical technique. Unlike conventional statistical methods, it does not require any assumptions about the underlying distributions of the data, making it a versatile tool for various types of analysis [91]. Additionally, it is highly flexible and can be applied to any kind of cross-tabulation, allowing for researchers to effectively explore the associations between variables [91]. Moreover, unlike other multidimensional scaling techniques, correspondence analyses are suitable for categorical and qualitative data, preserving the distributional characteristics of the initial variables while investigating associations [93]. This multivariate technique enabled this study to visualise the associations among smart city dimensions and sub/intermediary regions and to capture both strong and weak associations, allowing for the identification of associations based on the proximity on the correspondence map.

To answer the fourth question—Which factors contribute to regional differentiations of smart cities?—the results derived from the descriptive statistics and statistical analyses were then discussed, referring to the economic, social, and technological indicators of sub/intermediary regions (Table A2) to increase the explanatory capacity of the study. These discussions supported the development of context-depended policy implications at the sub/intermediary regional scale.

3. Results

The cities listed in the SCI-2023—a total of 141 cities—are located in 71 different countries all over the world (Figure 4), which reveals the capacity of the SCI-2023 to conduct research in the global context. The majority of the countries have only one city in the SCI-2023, whereas 35% of them have more than two cities (Figure 5). Considering the population sizes and coverage areas of the countries, the SCI-2023 represents specific countries with more than one city, such as China, the United States, the United Kingdom, and Germany. The SCI-2023 also reflects a strong representative level in terms of global regions. Out of the 71 countries, 38 are in the Global North, which is home to 83 smart cities, while the

33 countries in the Global South host 58 smart cities (Table A3). The SCI-2023 includes cities from all UNSD continental regions; however, 6 out of the 22 sub/intermediary regions are not represented: Middle Africa and Central Asia, as inland intermediary regions of the Sub-Saharan Africa subregion, and the Caribbean, Melanesia, Micronesia, and Polynesia, as small island subregions of Oceania.

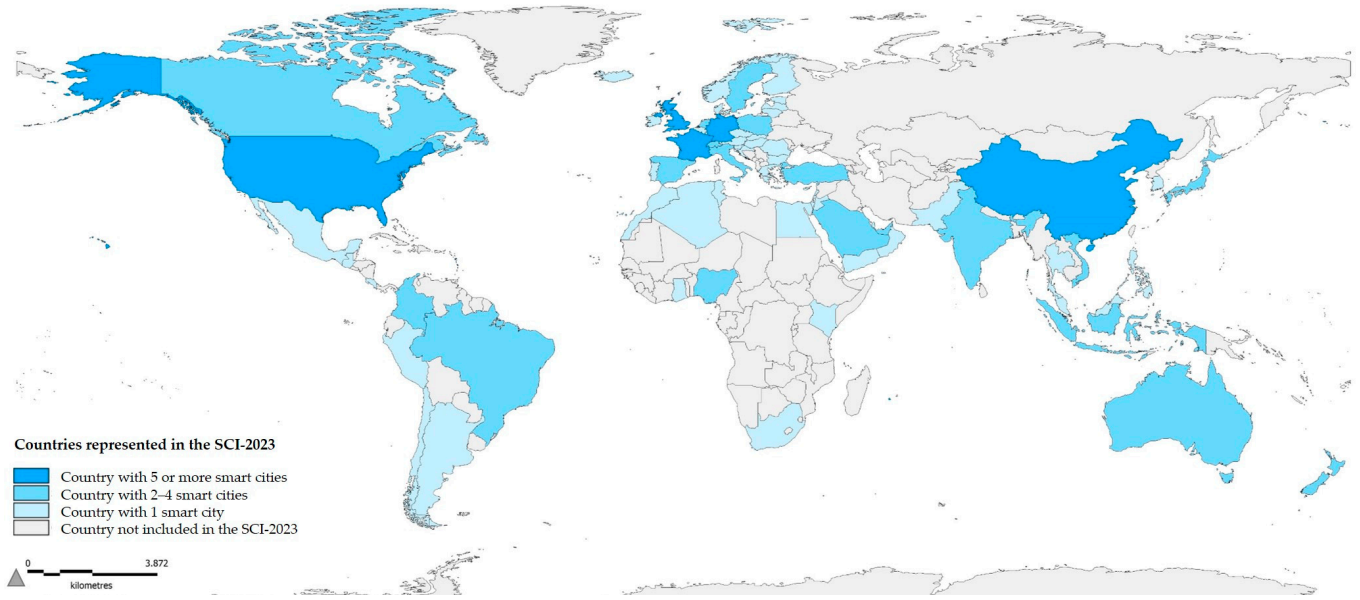


Figure 4. Geographical distribution of countries represented in the SCI-2023.

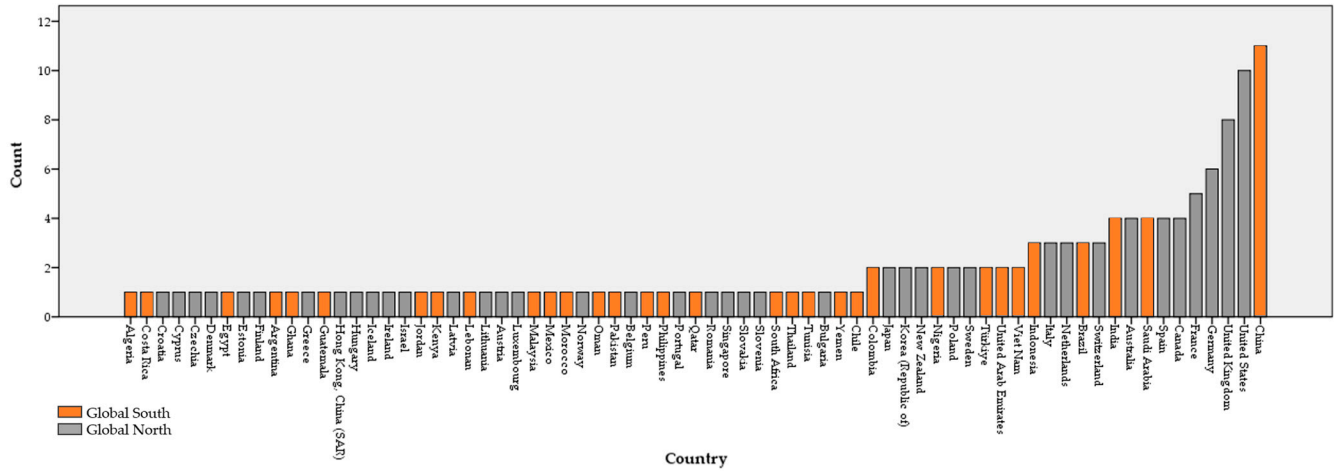


Figure 5. Statistical distribution of countries concerning the total number of cities in the SCI-2023.

The distribution of cities across regions (Figure 6, Table A4) reveals that Europe exhibits the highest proportion of cities, at 56.9%, while Oceania demonstrates the lowest at, 6.9%. The under-representation of Oceania results from the exclusion of small island countries from the SCI-2023. Regional differentiations in representation are also observable at the sub/intermediary regional scale. Certain sub/intermediary regions are under-represented, specifically intermediary regions of Sub-Saharan Africa, along with Southern Asia, while the highest concentration of cities is observed in the European subregions, except in Southern Europe.

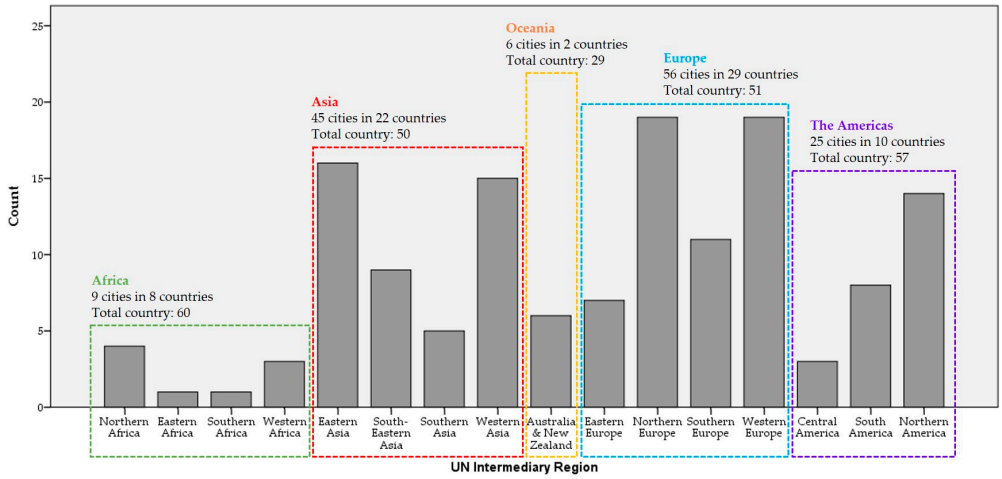
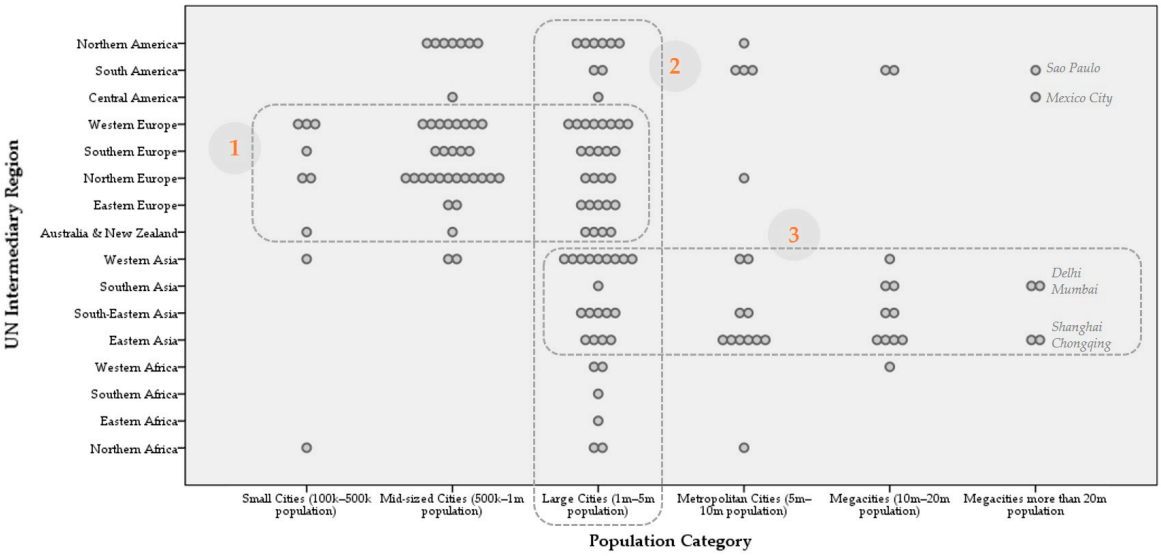


Figure 6. Geographical distribution of the total number of cities in the SCI-2023 considering sub/intermediary region breakdowns.

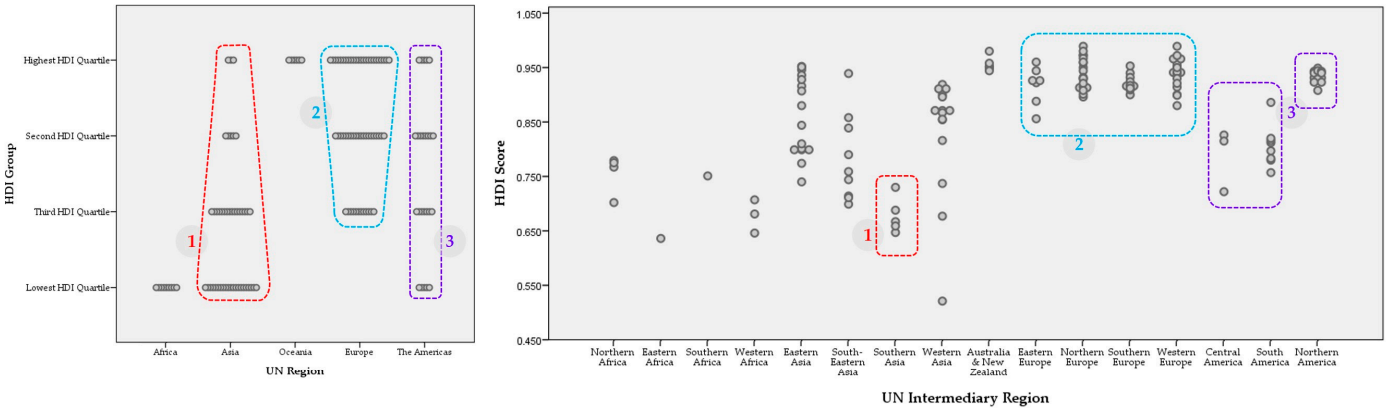
The cities listed in the SCI-2023 exhibit a range of population sizes (Table A5). There are six megacities with a population exceeding 20 million; Shanghai ranks first, with a population of 28,516,903. There are nine small cities with a population under 500,000, with Luxembourg having the smallest, at 120,000. The majority of cities in the SCI-2023 are large cities, with a population ranging from 1 million to 5 million, followed by mid-sized cities with a population ranging from 500,000 to 1 million. The geographical distribution of cities by population size (Figure 7) reveals that small cities with a population under 500,000 are predominantly located in Europe. In contrast, megacities, which are characterised by populations exceeding 10 million, are primarily located in the Americas and Asia. Large cities are prevalent globally, with a notable concentration in Europe, particularly in the Western subregion. The European subregions, along with the Australia & New Zealand subregion, lack large cities with a population exceeding 5 million, whereas Asia comprises cities with a population exceeding 1 million.



Group 1 : There are no metropolitan cities in the Europe continental region, and also in Australia & New Zealand subregion.
Group 2 : Majority of cities in the SCI-2023 are large cities with 1–5 million population.
Group 3 : All the Asian cities in the SCI-2023 are large cities with more than 1 million population.
2/3 of megacities with more than 20 million population are in Asia.

Figure 7. Geographical distribution of cities in the SCI-2023 according to population size groups.

The regional distribution of cities in the SCI-2023 based on HDI groups (Figure 8a) indicates that Africa ranks lowest, with nine smart cities being located in the lowest HDI quartile relative to other regions. Asia presents an intriguing situation, as the majority of cities fall within the third and lowest quartiles, with only three cities positioned in the highest quartile. On the contrary, the majority of European cities are in the highest or second quartile. An analysis of sub/intermediary regions based on HDI score (Figure 8b) reveals that the three highest-ranking smart cities are in Eastern Asia, while Southern Asia exclusively contains cities in the lowest quartile. The majority of smart cities are located in Europe, with 24 out of 56 cities being positioned in the highest quartile and 20 cities being located in the second quartile. The Oceanian cities, all of which are in the highest quartile, yield another significant result. The distinction between the southern and northern subregions of the Americas is clearly evident. Smart cities in the first two quartiles are situated in the Northern America subregion, while those in the third and fourth quartiles are located in the Latin America & the Caribbean subregion.



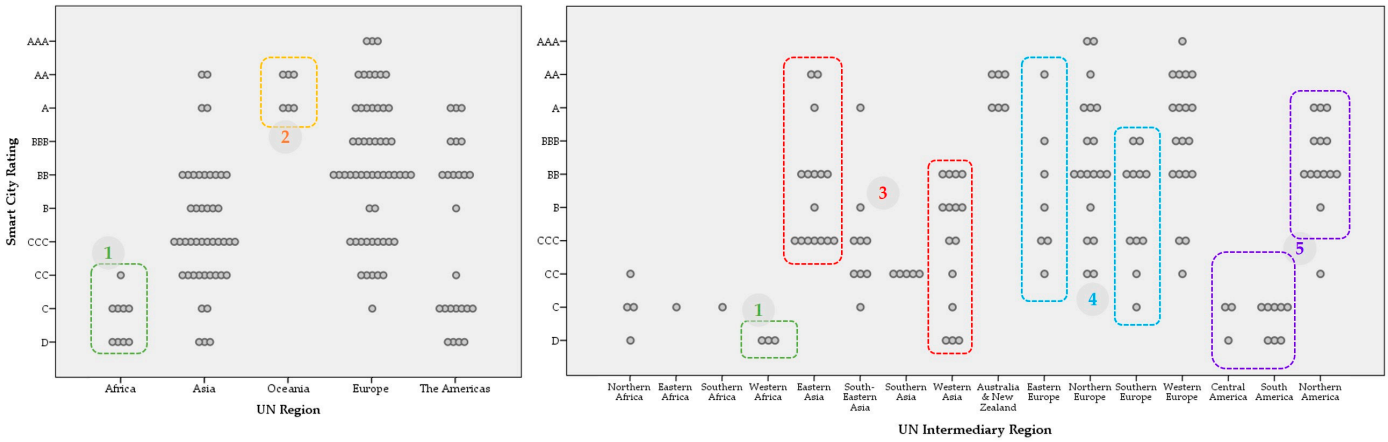
Group 1 : Asian cities accumulate in the lowest HDI quartiles with a decreasing trend towards higher quartiles. Examining the distribution of cities according to HDI scores in the subregional scale reveals the reason: Southern Asia subregion represents a different position than other subregions in Asia according to HDI scores of smart cities.
Group 2 : Despite there is the accumulation of European cities in higher HDI quartiles, the distribution of cities in subregional scale reveals that there is no identical differentiation between European subregions.
Group 3 : The HDI quartile distribution in the Americas has a balanced distribution, yet the distribution of cities based on their HDI scores in sub/intermediary regional scale clearly indicates the differentiation between northern and southern sub/intermediary regions of the Americas.

(**a**) (**b**)

Figure 8. Geographical distribution of cities in the SCI-2023 according to (**a**) the HDI groups in the continental regions; (**b**) HDI scores in the sub/intermediary regions.

The geographical distribution of cities in the SCI-2023 based on their smart city ratings (Figure 9a) reveals that the Oceanian cities exhibit higher smart city ratings, while the African cities are characterised by lower ratings. The distribution across Asia, Europe, and the Americas is notably dispersed, with a concentration of cities exhibiting higher ratings in Europe, while mid-level ratings are predominantly found in Asia. Examining the sub/intermediary regional distribution (Figure 9b), the highest ratings in Asia are observed in the Eastern Asia subregion. In the Americas, a clear distinction is evident between the northern and southern sub/intermediary regions, with higher ratings being concentrated in the north and lower ratings in the south. The geographical distribution of technology ratings reveals similar results to those obtained for the smart city ratings (Figure 10a). The African cities exhibit lower technology ratings, whereas cities in Oceania demonstrate higher technology ratings. Cities with diverse technology ratings exist in Asia, Europe, and the Americas; however, this distribution is not balanced when considering the sub/intermediary regions (Figure 10b). Differentiations in technology ratings are observed across the subregions of Asia, reflecting the western and eastern distinction, as well as within the Americas, highlighting the northern and southern

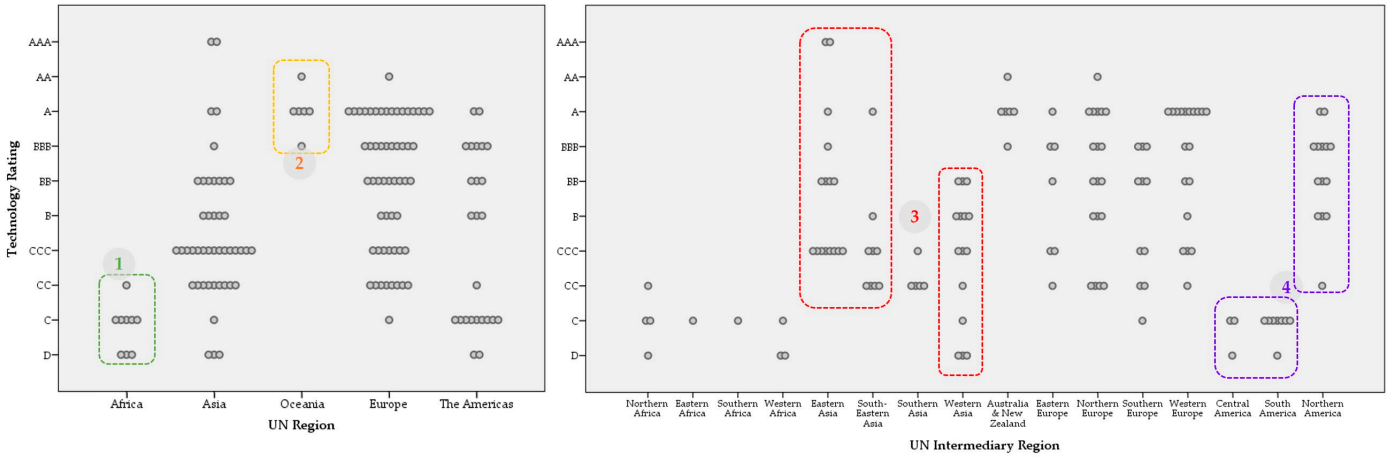
differentiation. The comparative examination of smart city and technology ratings demonstrates a kind of relationship between smartness level and technological capacity, necessitating further examination.



Group 1 : African cities in the SCI-2023 have the lower smart city ratings. Western Africa has only the lowest smart city rating cities.
Group 2 : All the cities in Oceania have higher smart city ratings.
Group 3 : The cities in Asia are more concentrated in the mid-levels of smart city ratings. In the subregional scale, the cities in Eastern Asia disperse towards higher ratings, whereas the cities in Western Asia towards lower ratings.
Group 4 : The European cities are mostly concentrated in the mid-levels of smart city ratings. In the subregional scale, the cities in Eastern Europe represents a balanced distribution, whereas the cities in Southern Europe towards lower ratings.
Group 5 : The distribution of cities in the Americas clearly indicates the differentiation between northern and southern sub/intermediary regions in terms of smart city ratings.

(**a**) (**b**)

Figure 9. Geographical distribution of cities in the SCI-2023 according to smart city rating (**a**) in the continental regions and (**b**) in the sub/intermediary regions.



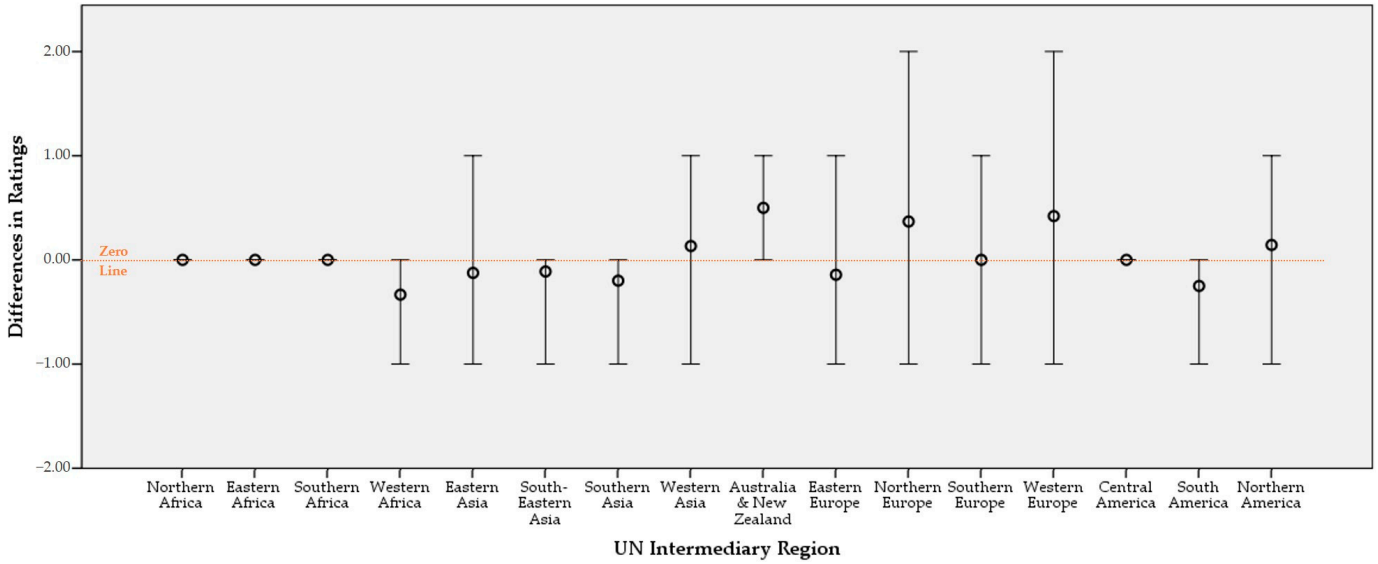
Group 1 : All African cities in the SCI-2023 have lower technology ratings.
Group 2 : All cities in Oceania have higher technology ratings.
Group 3 : The Asian cities are more concentrated in the mid/low-levels of technology ratings. However, in the subregional scale, the cities in Eastern and South-Eastern Asia disperse towards higher ratings, whereas the cities in Western Asia towards lower ratings.
Group 4 : The distribution of cities in the Americas clearly indicates the differentiation between northern and southern sub/intermediary regions in terms of technology ratings.

(**a**) (**b**)

Figure 10. Geographical distribution of cities in the SCI-2023 according to technology rating (**a**) in the continental regions and (**b**) in the sub/intermediary regions.

In smart city literature, technology is stated to be the main driver of smart cities; therefore, similar patterns are expected to be observed between the smart city and technology ratings. Examining the mean values of the differences between the smart city and technology ratings indicates the higher capacity of specific sub/intermediary regions, namely Northern and Western Europe and Australia & New Zealand, to translate their technological capacities into smartness levels (Figure 11, Table A6). On the contrary, all

Asian subregions, along with the South America and Eastern Europe sub/intermediary regions, present negative mean values, which means that they have lower smartness levels with regard to their technological capacities.



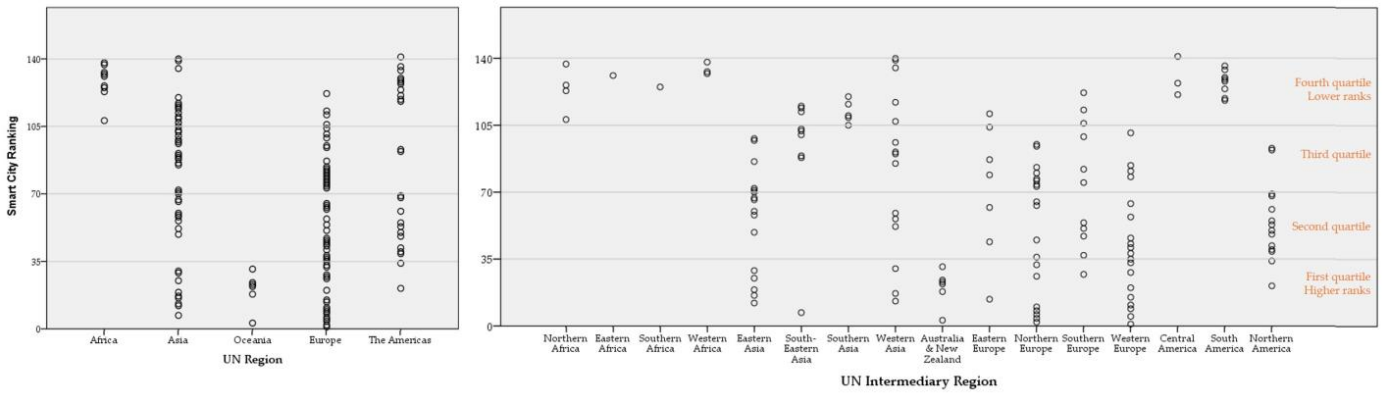
Notes: Differences in ratings are obtained by subtracting technological rating value from smart city rating value.
Positive/negative positions of the mean values (indicated by circles) according to the zero line (indicated by orange) refer higher/lower smartness level than technological capacities.
The vertical lines represent the highest-lowest values in respective sub/intermediary regions. The longer the line, the more variety observed in the differentiations.

Figure 11. The difference between the smart city ratings and technology ratings of cities in the SCI-2023 at the sub/intermediary regional scale.

The distribution of smart city rankings indicates a balanced representation in Asia and Europe (Figure 12a,b). Both continental regions feature smart cities that are categorised into distinct ranking groups; however, European smart cities are predominantly found in the first quartile, while Asian cities are primarily located in the middle of the ranking list. Asia encompasses the cities ranked highest as well as those ranked the lowest; however, only a limited number of cities were found in the top ten or top twenty lists (Table A7). Europe exhibits a diverse range of smart cities, with nearly one-fourth of them positioned within the top 20 rankings. This suggests a relatively uniform level of development throughout Europe, especially when compared to Asia. The northern and southern differentiation is again evident in the Americas. Cities in the Northern America subregion predominantly occupy the upper half of the ranking list, while those in the Latin America & the Caribbean subregion are primarily found in the lower half. Nearly all African cities are positioned at the lower end of the rankings, with eight out of nine cities falling within the bottom 20. In contrast, cities in Oceania occupy the top positions, with all of them placed in the first quarter of the ranking list.

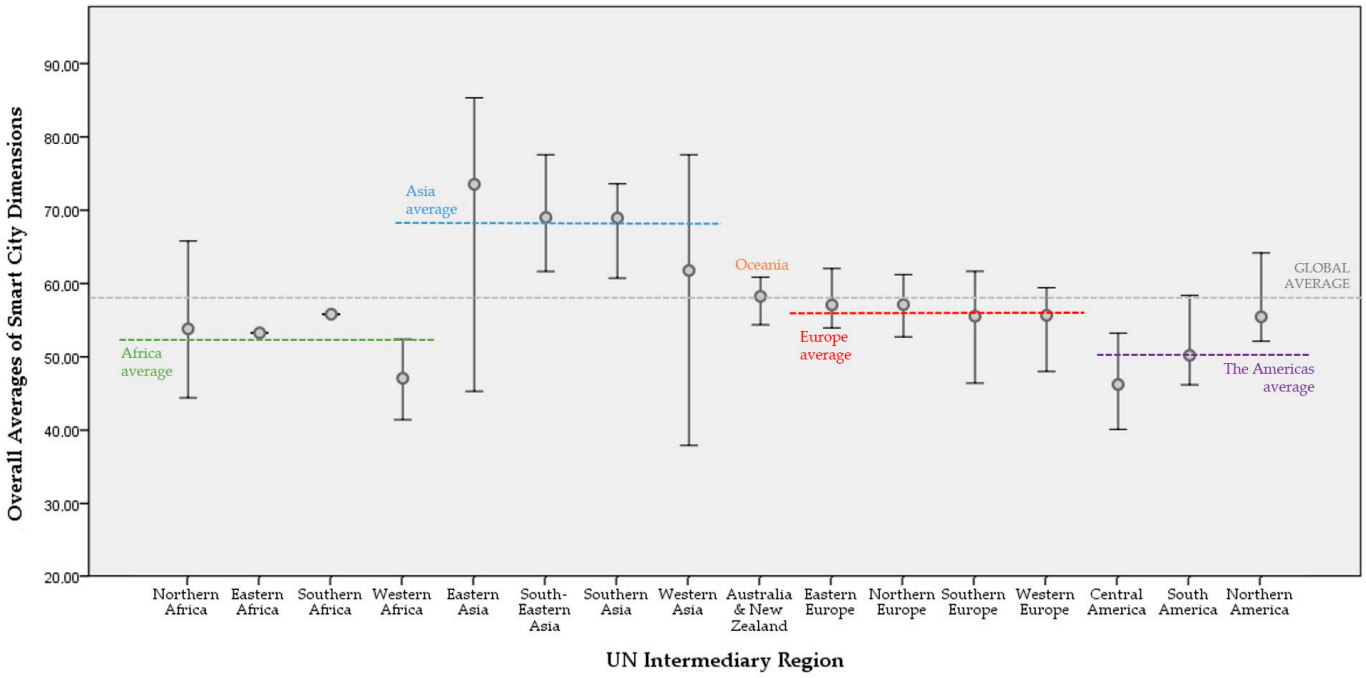
An evaluation of sub/intermediary regions in relation to the overall average smart city dimensions (Figure 13) indicates that Europe exhibits a similar clustering of subregions around the overall regional average, which closely aligns with the global average. Oceania is represented in only one subregion, and its overall average is comparable to the global average. Nonetheless, sub/intermediary regional differentiations are evident in other regions. Southern Africa exhibits a lower overall average compared to the overall average for Africa, while Northern Africa surpasses this average. Comparable outcomes are observed in the sub/intermediary regions of the Americas, characterised by a distinct northern and southern differentiation. The dominance of Asian smart cities is evident when evaluating the overall average of smart city dimensions. Asian subregions exhibit the highest overall averages, surpassing the global average and that

of all other subregions, with Eastern Asia at the forefront, whereas Western Asia exhibits lower overall averages compared to other subregions in Asia.



(**a**) (**b**)

Figure 12. Geographical distribution of cities in the SCI-2023 according to smart city ranking (**a**) in the continental regions and (**b**) in the sub/intermediary regions.



Notes: Overall averages are computed by averaging of all smart city dimensions in the respective scale.
Mean values are indicated by circles for the respective sub/intermediary region.
The vertical lines represent the highest-lowest overall averages in respective sub/intermediary region.
The horizontal lines represent the overall averages of continental regions. Oceania has no overall average as being represented by only one subregion.

Figure 13. Overall averages of smart city dimensions, represented by the minimum, maximum, and mean values for each sub/intermediary region in comparison with the overall averages of continental regions and the world.

The correlation matrix indicates strong and statistically significant positive relationships (at the 0.01 level) between smart city dimensions at the sub/intermediary regional scale (Figure 14). The Pearson correlation coefficients range from 0.708 to 0.970, indicating strong relationships between the smart city dimensions. Notably, the smart mobility and smart living dimensions exhibit the highest correlation coefficient (r = 0.970). Both dimensions also display very strong relationships with the smart governance dimension.

The smart governance and smart mobility dimensions display very strong relationships with three other dimensions. Those dimensions are smart mobility, smart living, and smart environment for the smart governance dimension, and smart living, smart governance, and smart environment for the smart mobility dimension. The smart living and smart environment dimensions have very strong relationships with two other dimensions, which are smart governance and smart mobility. However, the smart people and smart economy dimensions do not exhibit very significant relationships with other dimensions, as their correlation coefficients are lower than 0.900—the weakest is the relationship between smart people and smart environment (r = 0.708).

Correlations

		Smart People	Smart Governance	Smart Economy	Smart Living	Smart Environment	Smart Mobility
Smart People	Pearson Correlation	1	0.842**	0.861**	0.891**	0.708**	0.873**
	Sig. (2-tailed)		0.000	0.000	0.000	0.002	0.000
	N	16	16	16	16	16	16
Smart Governance	Pearson Correlation	0.842**	1	0.895**	0.954**	0.954**	0.965**
	Sig. (2-tailed)	0.000		0.000	0.000	0.000	0.000
	N	16	16	16	16	16	16
Smart Economy	Pearson Correlation	0.861**	0.895**	1	0.856**	0.863**	0.899**
	Sig. (2-tailed)	0.000	0.000		0.000	0.000	0.000
	N	16	16	16	16	16	16
Smart Living	Pearson Correlation	0.891**	0.954**	0.856**	1	0.878**	0.970**
	Sig. (2-tailed)	0.000	0.000	0.000		0.000	0.000
	N	16	16	16	16	16	16
Smart Environment	Pearson Correlation	0.708**	0.954**	0.863**	0.878**	1	0.902**
	Sig. (2-tailed)	0.002	0.000	0.000	0.000		0.000
	N	16	16	16	16	16	16
Smart Mobility	Pearson Correlation	0.873**	0.965**	0.899**	0.970**	0.902**	1
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	
	N	16	16	16	16	16	16

**. Correlation is significant at the 0.01 level (2-tailed).

Notes: The correlation analysis is computed by referring to the scores of smart city dimensions in the sub/intermediary regional scale. The scores for sub/intermediary regions are calculated by taking average scores of smart city dimensions of all cities within that respected sub/intermediary region.
Very strong relationships between dimensions are highlighted by background colour.

Figure 14. The correlation matrix between smart city dimensions at the sub/intermediary scale—very significant relationships ($r \geq 0.900$) for each dimension are highlighted by background colour.

Concerning the positions of the smart city dimensions on the correspondence map (Figure 15), there exist notable strong and weak associations among the smart city dimensions, aligning closely with the relationships identified in the correlation matrix. The strongest association was that between the smart living and smart mobility dimensions owing to their proximity to each other. They are not only situated closely but also centrally. Such central positions on correspondence maps imply associations with other dimensions that gradually decrease. The smart living dimension is primarily associated with smart people and secondarily with smart economy. The smart mobility dimension is similarly linked to smart governance. The smart environment dimension is distinctly separated on the correspondence map, indicating that it possesses the weakest associations with other dimensions. Aside from the weak association with smart governance, it exhibits no substantial associations with any other smart city dimensions. A similar association is observed for the smart economy dimension; it has a distinct location on the correspondence map and a weak association with only one dimension, namely smart people.

The positioning of smart city dimensions on the correspondence map further echoes the results of the correlation analysis. The positions of the smart people and smart economy dimensions on the correspondence map exhibit similar outcomes to the correlation matrix, with weak relationships with other dimensions. However, the smart environment dimension, which displays a very significant relationship with smart governance on the correlation matrix, exhibits a different result, with a more separate location on the correspondence map. Regardless of the minor variances in the results of the correlation and correspondence analyses, it can be concluded that the smart city dimensions are interconnected and exhibit strong associations.

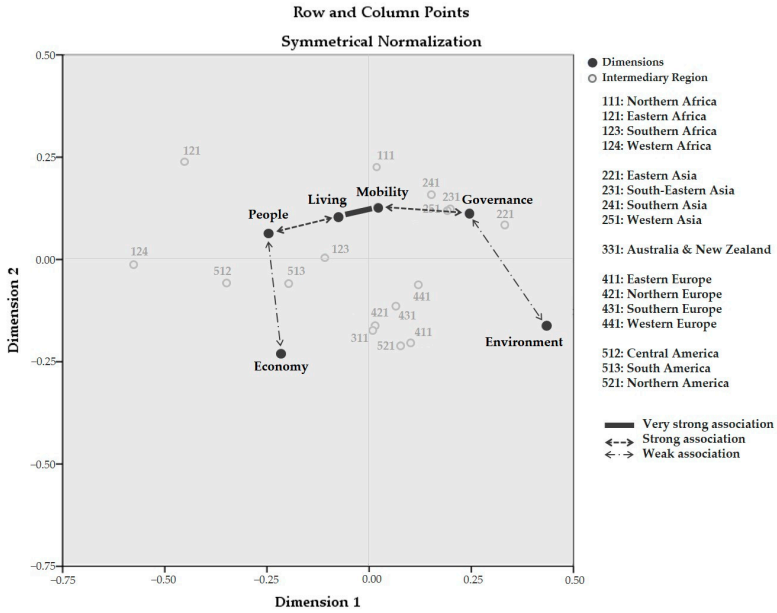


Figure 15. The conceptual representation of the associations among smart city dimensions on the correspondence map.

The correspondence map serves as an essential instrument for evaluating the associations among smart city dimensions as well as the associations among smart city dimensions and sub/intermediary regions (Figure 16). The correspondence map identified four areas of concentrations: the first association group encompasses all subregions in Europe, Australia & New Zealand, and Northern America, specifically the Global North, exhibiting an equi-distant association with almost all dimensions. The second association group encompasses all subregions of Asia that have a very strong association with the smart governance dimension. The third group encompasses the intermediary regions of Latin America & the Caribbean, linked to the smart people and smart economy dimensions. The fourth association group includes the sub/intermediary regions of Africa that have a reduced concentration, with varying associations to distinct smart city dimensions.

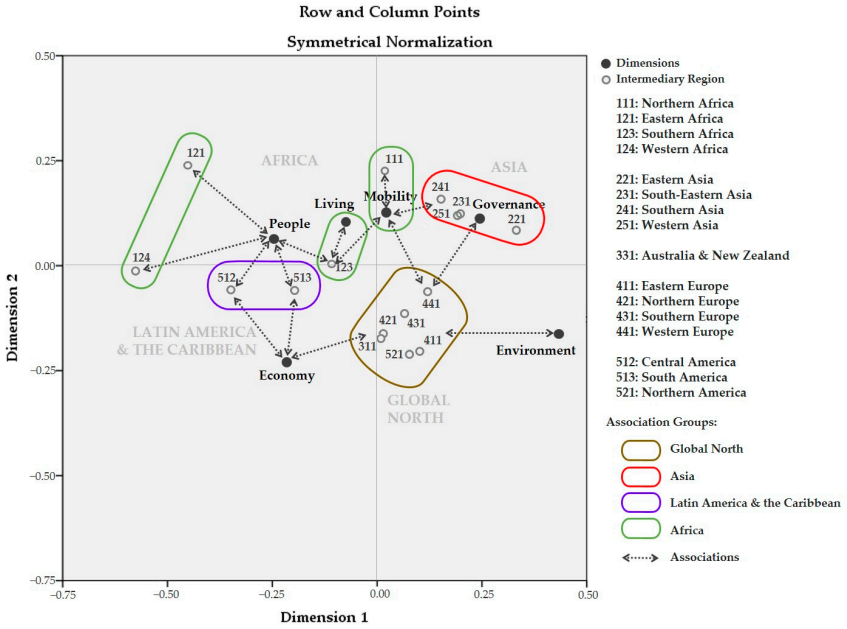


Figure 16. The conceptual representation of the associations among the smart city dimensions and sub/intermediary regions on the correspondence map.

There is a remarkable concentration of sub/intermediary regions in the Global North, including Australia & New Zealand, Northern America, and Eastern, Northern, Southern, and Western Europe (Figure 17). This concentration does not exhibit very strong associations with specific smart city dimensions, but shows a comparable distance from all dimensions—when arranged in a circular formation—except the smart people dimension, which has a weaker association compared to other dimensions, being more distant from the central circle. Upon close examination of this association group, it is evident that Northern Europe has considerably stronger associations with smart governance and smart mobility, while Eastern Europe and Northern America are associated with smart environment, and Australia & New Zealand and Northern Europe are linked to smart economy. Differing from the other subregions, Southern Europe has no specific association with any dimensions but stands at an equi-distant position.

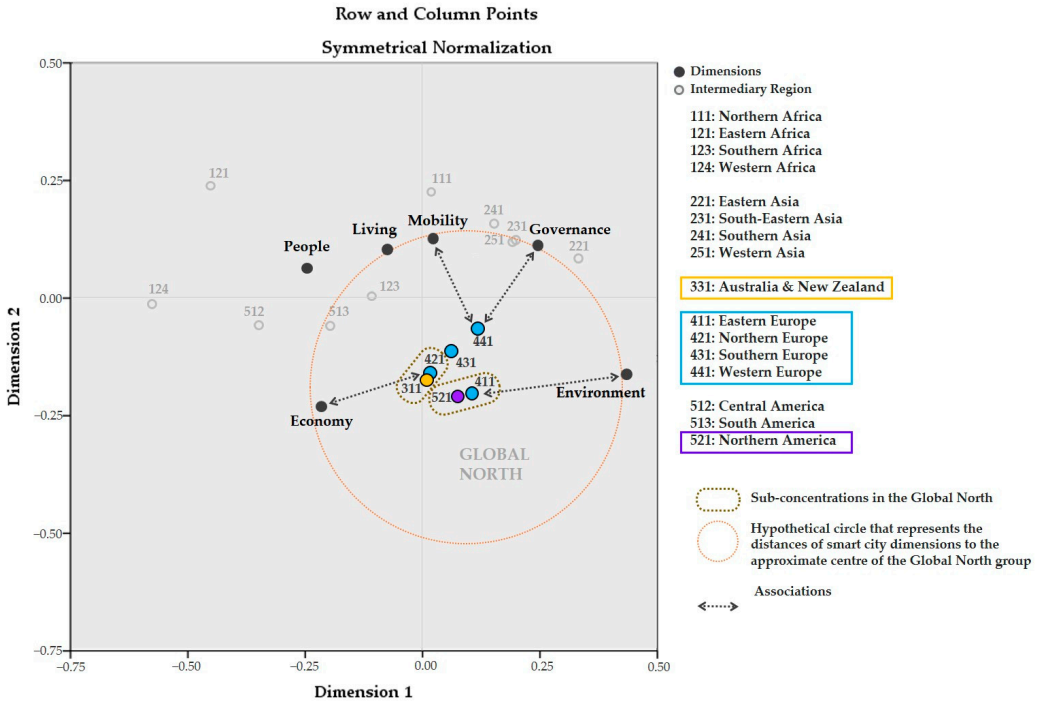


Figure 17. The conceptual representation of the associations among smart city dimensions and sub-concentrations in the Global North.

Another significant concentration was observed among the Asian subregions, but this differed to the Global North concentration, being mainly linked to a singular smart city dimension, namely, smart governance (Figure 18). Considering that the degrees of these associations vary according to the positions of the subregions on the correspondence map, the South-Eastern and Western Asia subregions have similar characteristics, as they nearly overlap on the correspondence map, and both demonstrate very strong associations with the smart governance dimension. Nonetheless, these associations are comparatively weaker for the Eastern and Southern Asia subregions. Southern Asia exhibits a weak association with the smart mobility dimension, whereas Eastern Asia demonstrates a weak association with the smart environment dimension. These diverse associations and different positions of the Eastern and Western Asia subregions are parallel with the findings of the descriptive statistics, demonstrating the regional differentiations within Asia, and the west and east differentiation.

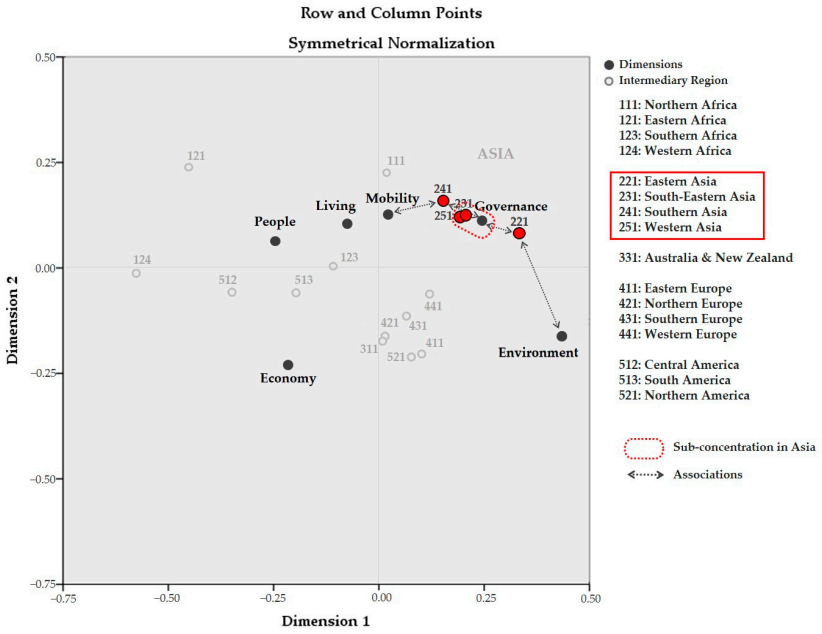


Figure 18. The conceptual representation of the associations among smart city dimensions and sub-concentrations in Asia.

A notable concentration can be seen among the intermediary regions of Latin America & the Caribbean subregion of the Americas (Figure 19). These intermediary regions, namely Central and South America, are strongly associated with the smart people and smart economy dimensions. Given that these regions exhibit comparable distances from these dimensions on the correspondence map, the levels of association are thus similar. The regional differentiation indicated by the descriptive statistics regarding the northern and southern differentiation in the Americas is also evident in this analysis. The Northern America subregion, which aligns with the European subregions and Australia & New Zealand on the correspondence map, features associations that are markedly different from those of the Latin America & the Caribbean subregion.

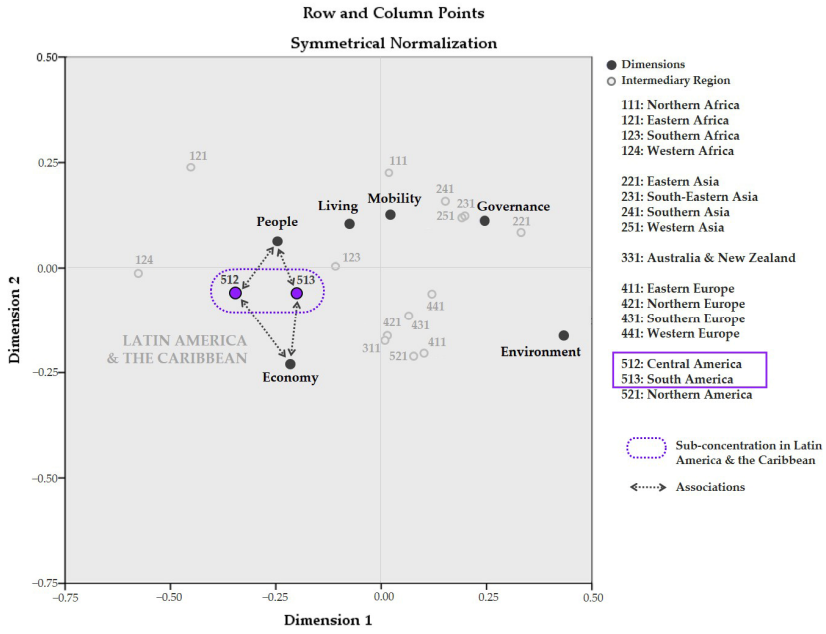


Figure 19. The conceptual representation of the associations among smart city dimensions and sub-concentrations in Latin America & the Caribbean.

The associations among smart city dimensions and sub/intermediary regions are particularly varied and dispersed over Africa (Figure 20). One of the strong associations in the correspondence map for Africa is between the smart mobility dimension and Northern Africa, with no other notable associations with any additional dimensions. The second strong association is between the smart living dimension and Southern Africa. This is not the only associated dimension; Southern Africa is also associated with the smart people and smart mobility dimensions. The Southern Africa intermediary region is distinctive within Sub-Saharan Africa because of these associations. The other African intermediary regions, particularly Eastern and Western Africa, are more distant from the smart city dimensions and other sub/intermediary regions. Their isolated position results in their only having a weaker association with the smart people dimension. The positions of sub/intermediary regions in Africa and their associations with the smart city dimensions on the correspondence map indicate that the dynamics of Africa differ from those of other continental regions.

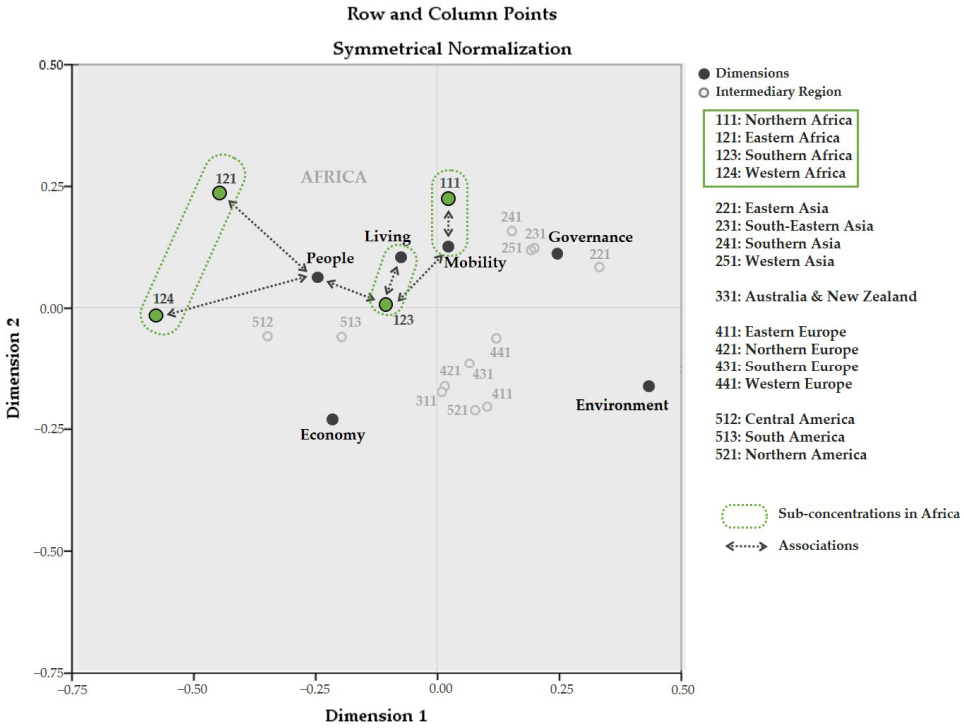


Figure 20. The conceptual representation of the associations among smart city dimensions and sub-concentrations in Africa.

4. Discussion

The study commenced by examining the complex domain of smart cities, exploring diverse definitions and dimensions to establish a theoretical framework. The literature review indicated that there is no single and universally accepted definition of the smart city concept but a consensus on two issues: (1) the importance of technology in formulating the smart city and (2) the multi-dimensional and interrelated nature of the smart city dimensions. Previous studies mention the differentiations among countries or regions in smart city implementations, especially concerning smart city dimensions; however, the few studies conducted research in the global context. Aiming to address this research gap, this study explored the regional differentiations and the associations between sub/intermediary regions and smart city dimensions in the global context by using the SCI-2023 data, a global index assessing the smartness level of cities all over the world and ranking them accordingly. The descriptive statistics revealed that the SCI-2023 has a strong capacity and sufficient

inclusiveness to conduct research on smart cities worldwide, with the following attributes: (1) a sufficient number of cities from the Global North and South, with 38 and 33 countries, respectively; (2) the ability to represent 71 countries out of 247 with at least one city; (3) the inclusion of all continental regions and 16 sub/intermediary regions out of 22; and (4) the inclusion of cities with varying populations (Tables A3–A5).

The results exhibit the following key findings: (1) there is a clear distinction not only between the Global North and South but also between sub/intermediary regions; (2) the smart city dimensions are interconnected; and (3) specific groups of concentrations exist, which delineate the associations among sub/intermediary regions and smart city dimensions. All key findings verify the regional differentiations of smart cities in the global context. In order to discuss the factors contributing to these differentiations, the economic, social, and technological indicators of sub/intermediary regions (Table A2) are further evaluated along with the research findings.

4.1. Interpretation of Key Findings

Smart cities are profoundly concentrated in the more developed regions, particularly in Oceania, Europe, and Northern America, which host the highest number of smart cities with higher smart city and technology ratings. This aligns with the findings of previous research [56] indicating that cities in the Global North support smart city implementations as they have strong governance structures with better access to economic and technological resources. The higher smart city and technology ratings obtained for both the Europe and Oceania continental regions and also for the Northern America subregion support the findings of the previous research, suggesting that investments in digital infrastructure play a critical role in shaping the success of smart cities [54]. These regions have a strong ability to translate their technological capacity into smart city implementations as they have higher smart city ratings than technology ratings. In addition to the Global North, Asia is identified as one of the leading continental regions in smart city development. In contrast, the Africa continental region and the Latin America & the Caribbean subregion display lower smart city ratings and rankings, reinforcing concerns about the economic, social, and technological challenges in these regions. This study further examined and compared these regions to further previous discussions on the Global North–South divide. The geographical analysis of smart cities clearly indicated significant sub/intermediary regional differentiations.

A noteworthy finding regarding sub/intermediary regional differentiation is the existence of certain divides: (1) the North–South divide in the Americas and (2) the East–West divide in Asia. Northern America outperforms Latin America & the Caribbean in smart city dimensions, with higher technology ratings and rankings. Similarly, Eastern Asia exhibits a higher smart city performance compared to Western Asia, with the lowest economic, social, and technological indicators within the continental region. Differing from the research indicating a clear East–West divide in Europe in terms of smart city performance [50], this study does not verify such a differentiation; instead, Northern and Western Europe performed similarly, whereas Southern and Eastern Europe reflected different patterns within Europe in terms of smart city and technology ratings. High-income regions, such as Northern America, Western Europe, and Australia & New Zealand, with a significantly higher gross domestic product (GDP) per capita, demonstrate a strong digital infrastructure and high research and development (R&D) investments, facilitating advanced smart city initiatives. In contrast, regions with a lower GDP per capita, like Sub-Saharan Africa and Southern Asia, face digital and infrastructural limitations, hindering the widespread implementation of smart technologies. The low levels of internet connection in Sub-Saharan Africa (37 per 100 people) and Southern Asia (44.3 per 100 people), compared to 97.3 in

Northern America or 95.6 in Western Europe, illustrate the digital divide, which limits the effectiveness of digital governance, mobility solutions, and smart environmental management. In addition to the availability of technology, this gap is also observable in R&D investments, with Northern America investing 3.3% of GDP, while the investments from Sub-Saharan Africa and Southern Asia remain below 0.5%. Advanced economies have a greater financial capacity for infrastructure investments and digital transformation, while developing regions may struggle due to their reliance on traditional sectors. Moreover, the digital divide remains a major barrier for smart city development in the Global South. Investment in digital infrastructure is crucial to bridge this gap. On the other hand, social factors, such as urbanisation rates, education, and healthcare access, significantly influence the feasibility of smart city implementations. Highly urbanised regions, such as Northern America (82.4%), have a natural advantage in implementing smart city frameworks, while less urbanised regions, such as Sub-Saharan Africa (40.9%) and Southern Asia (39.6%), require tailored solutions. Moreover, social indicators, such as higher life expectancy, lower mortality rates, and better access to education services, pair themselves with more developed regions, which are correlated with higher smart city ratings. These results support the findings of previous research examining the relation between urban attractiveness and smart characteristics in Italy, concluding that economic, social, and technological disparities influence the effectiveness of smart city strategies between specific regions [49]. These results also reinforce the argument by Alizadeh [56] that smart city development is shaped by regional socio-economic priorities.

One of the key findings of this study is the identification of strong associations among smart city dimensions—not all dimensions have a close relation to each other, but some dimensions are more influential when evaluating the smartness level of sub/intermediary regions. In line with the results of Barbierato and Gatti [40], smart living and smart mobility held the central position compared to other dimensions. The results presenting the strongest association among smart living and smart mobility emphasise the human-centred and infrastructural aspects of smart cities. This finding suggests that cities investing in digital mobility solutions, such as smart transportation systems and online public services, also enhance urban living experiences through digital governance and service accessibility. This finding complements previous research that emphasises the importance of integrated transport solutions and digital services for urban efficiency [74]. Meanwhile, the smart economy and smart environment, although still interconnected, appear to operate with some degree of independence. Specifically, the weak association between the smart environment and other dimensions indicates that environmental sustainability is often treated separately in smart city strategies. This aligns with previous critiques that smart city initiatives tend to prioritise economic and technological advancements over environmental concerns, and environmental sustainability often receives less emphasis in technology-driven urban policies [26,55]. These findings highlight the need for integrated strategies that prioritise governance-driven approaches to enhance mobility, environmental resilience, and overall quality of life in smart cities.

The strong association among the smart city dimensions identified by the correlation and correspondence analyses underlines the fact that the smart city development cannot be achieved based solely on a single dimension; rather, a comprehensive evaluation of multiple interrelated dimensions is required. This conclusion aligns with Hammoumi, Maanan, and Rhinane, who assert that "... it is the collective enhancement across governance, health, mobility, and technology that characterises truly smart cities" [74] (p. 1341). However, the prominence of the smart governance dimension in smart city performance should be addressed specifically. Despite not being in the central position on the correspondence map, smart governance could be considered a key driver [57,59], particularly influencing smart

mobility and smart environment, as exemplified by the Asian cities. This study detected a very strong association among all Asian subregions and the smart governance dimension. This very strong association could provide an explanation for the higher scores obtained by Asian cities compared to other sub/intermediary regions. This conclusion is reasonable considering the central role of governance in the implementation and provision of the services that trigger smart city development, and is aligned with previous research [44,55].

The regional differentiations in the smart city dimensions also provide important insights. The findings reveal that the regional differentiation of smart cities is not completely parallel to the United Nations' geographic regions. The results of the correspondence analysis displayed four association groups with distinct attitudes (Figure 21). The Global North group, including all subregions of Europe, Australia & New Zealand, and the Northern America subregions, showed roughly equal coverage of all dimensions. There are four sub-concentrations within the Global North. The subregions of the Europe continental region overlaps with the UNSD geographic region breakdown; however, interestingly, Northern America overlapped with Eastern Europe, and Australia and New Zealand with Northern Europe. The Asia group, including all Asian subregions as developing regions in the Global South, displayed a very strong association with the smart governance dimension. However, the sub-concentrations within this group reveal a distinct division between Western Asia and the other subregions of Asia. As the third group, the intermediary regions of the Latin America & the Caribbean subregion aligned more closely with the smart economy and smart people dimensions, which clearly overlaps with the UNSD geographic regions. Different from the other three groups exhibiting close associations with other sub/intermediary regions and/or smart city dimensions, the fourth group, Africa, has a dispersed nature in terms of associations. Northern Africa exhibits stronger associations with the smart mobility dimension, while cities in Southern Africa are linked to the smart living and smart people dimensions. Different from all other sub/intermediary regions, Western and Eastern Africa do not have strong associations, but have weak associations with the smart people dimension.

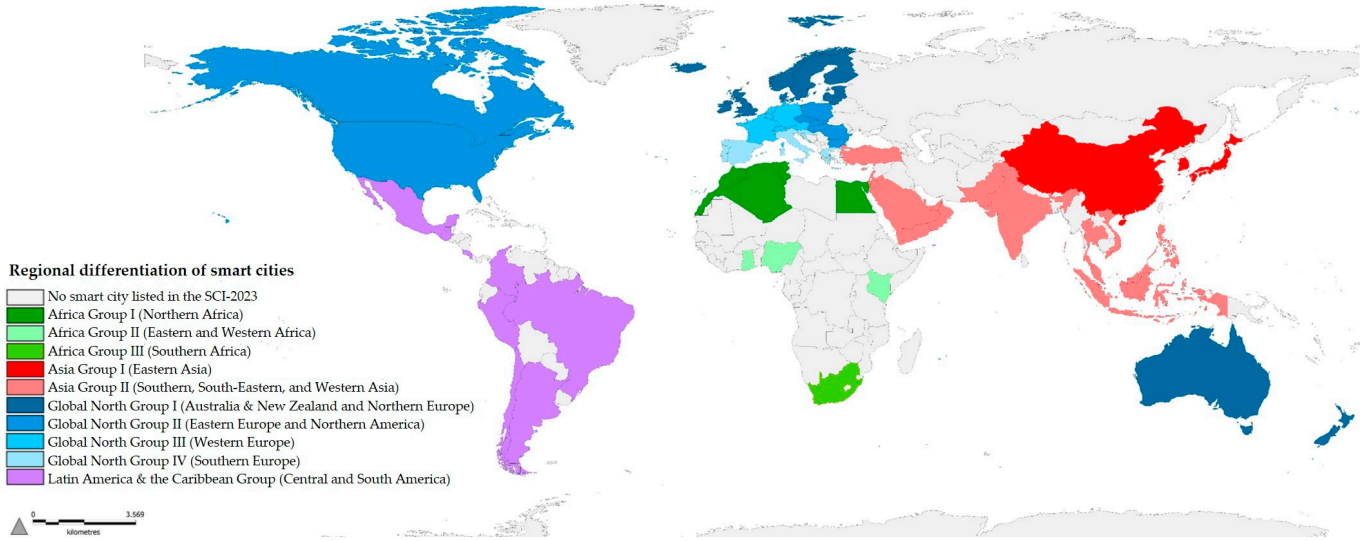


Figure 21. Regional differentiation of smart cities in the global context—the concentrations of the associations among smart city dimensions and sub/intermediary regions.

4.2. Implications of the Findings

The foremost practical policy implication of the study is the necessity for context-dependent smart city policies. Cities in the Global South should not imitate the models of the Global North; rather, specific smart city policies should be formulated that correspond with their economic and social contexts, as well as their technological capacities, as also proposed by Alizadeh [56]. However, it is essential to recognise that the relevant regional differentiation is not merely the Global North–South divide, but the differentiations that are observable at the sub/intermediary regional scale should also be taken into account when formulating strategies. Policymakers can be inspired by the achievements of other smart cities within their sub/intermediary regions. For instance, cities in Asia can focus on the smart governance dimension to obtain a better smart city performance, since this dimension has a stronger influence on the smartness levels in this region. Secondly, the weak association between the smart environment dimension and other dimensions indicates a policy deficiency in incorporating sustainability into smart city initiatives. Policymakers ought to implement cross-sectoral policies that integrate environmental issues with other digital features [58], such as smart mobility, by implementing sustainable transport systems to establish a comprehensive smart city framework. Lastly, the combined insights from correlation and correspondence analyses suggest that smart living and smart mobility hold a central position, and also have a strong association with the smart people dimension, which emphasises the social and infrastructural aspects of smart cities. Smart governance, on the other hand, acts as a key dimension, particularly influencing mobility and environmental sustainability. Distinctly, smart economy and smart environment appear to operate with some degree of independence, although they are still weakly connected.

These findings highlight the need for integrated strategies that prioritise governance-driven approaches to enhance mobility, environmental resilience, and overall quality of life in smart cities.

5. Conclusions

This study aimed to investigate the regional differentiations of smart cities by providing an analytical framework. Using the IMD Smart City Index 2023 as the data source, the study employed geographical and statistical methods to identify how smart city characteristics vary across regions worldwide and what factors shape these variations. The exploratory methodological and analytical frameworks detecting and mapping the complex associations among regions and dimensions provide a distinctive perspective in the smart city debates.

The findings of the study directly address the research questions outlined in the introduction. First, smart cities differ significantly across global regions, with the Global North generally exhibiting higher smart city and technology ratings than the Global South. Notable sub/intermediary regional differences were also observed, particularly for the East–West in Asia and the North–South in the Americas. Second, strong associations were found among smart city dimensions, particularly between smart living and smart mobility, suggesting that improvements in urban quality of life are closely tied to transportation, digital technologies, and related infrastructure. Third, the associations between smart city dimensions and specific regions showed clear patterns—Asian cities were more aligned with smart governance, while Latin American cities correlated more with the smart people and smart economy dimensions. Finally, these regional differentiations appear to be driven largely by regional disparities in economic, social, and technological development levels.

This study complements the previous research and contributes to the ongoing discourse on smart cities by presenting a novel viewpoint based on sub/intermediary regions. The results revealed significant differentiations in the distribution of smart cities across

regions, reinforcing previous researchers [56–58]. Notably, while previous studies have examined specific smart city dimensions [59], this research identified the interrelationships between dimensions and their associations with different regions. The results highlighted that certain dimensions are more associated with specific regions. Consistent with previous studies [46,48], this research confirmed that smart city development is not uniform; rather, it is shaped by economic conditions, social structures, and the available technological infrastructure. Through a globally comparative, multi-dimensional, and regionally sensitive perspective, this study emphasised the importance of context-dependent smart city strategies that align with each region's socio-economic conditions and technological capacities.

While contributing to smart city discussions from a different perspective, this study has certain limitations, specifically regarding its methodology. The SCI-2023 depends on perception-based data rather than objective performance metrics, which may introduce subjectivity and limit the accuracy of smart city performance measurements. Moreover, the fixed sample size of 120 citizens per city, regardless of the population, further constrains the representational capacity of the SCI-2023. Additionally, the SCI-2023 lacks coverage in regions such as Middle Africa and Central Asia, limiting its global inclusiveness. Future research could address these gaps by integrating performance-based indicators, expanding regional coverage, and adopting mixed-method statistical frameworks.

Further studies are required to examine the specific factors involved in the regional differentiations in smart city development. An in-depth analysis of governance frameworks, digital infrastructure, and economic incentives could provide a more nuanced understanding of why certain smart city dimensions are more influential in specific regions and why some regions outperform others. Moreover, analysing longitudinal trends using the time-series dimension of the SCI could reveal how smart cities change over time to help policymakers design adaptive strategies.

Author Contributions: Conceptualization, K.S.T. and Y.S.L.; methodology, K.S.T., Y.S.L. and T.L.; formal analysis, K.S.T., Y.S.L. and T.L.; data curation, K.S.T. and Y.S.L.; writing—original draft preparation, K.S.T.; writing—review and editing, Y.S.L. and T.L.; visualisation, Y.S.L.; supervision, Y.S.L. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

ICT	Information and Communication Technology
HDI	Human Development Index
GNI	Gross National Income
UNSD	United Nations Department of Economic and Social Affairs Statistics Division
SCI	IMD Smart City Index
SCI-2023	IMD Smart City Index 2023
IMD	International Institute for Management Development

WeGO	World Smart Sustainable Cities Organization
UNESCO	United Nations Educational, Scientific and Cultural Organization
UN-Habitat	United Nations Human Settlements Programme
GIS	Geographical Information System
GDP	Gross Domestic Product
R&D	Research and Development

Appendix A

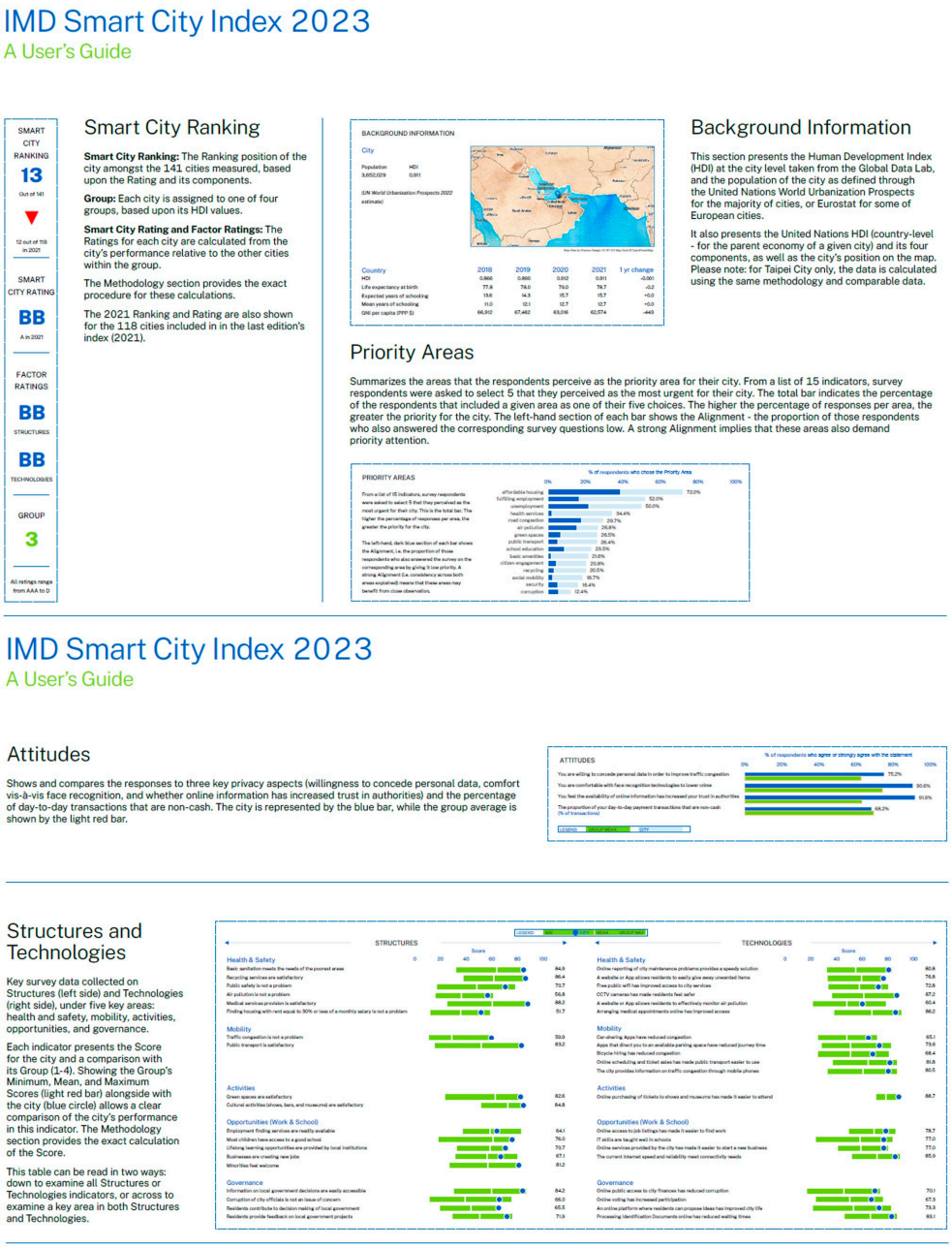


Figure A1. A user's guide to how to read the individual city card in the SCI-2023 [60] (p. 31–32).

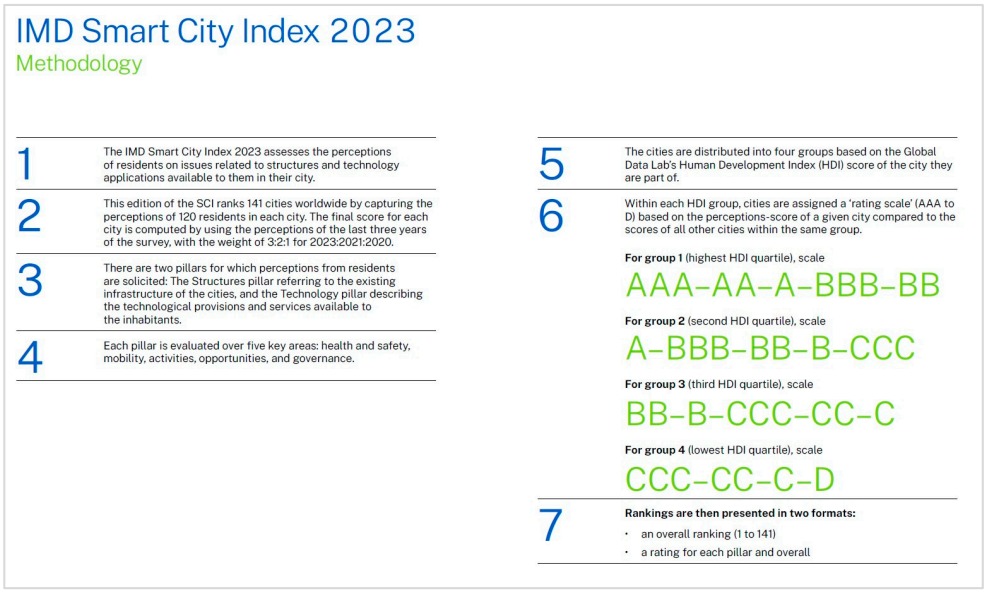


Figure A2. The methodology of the SCI-2023 [60] (p. 34).

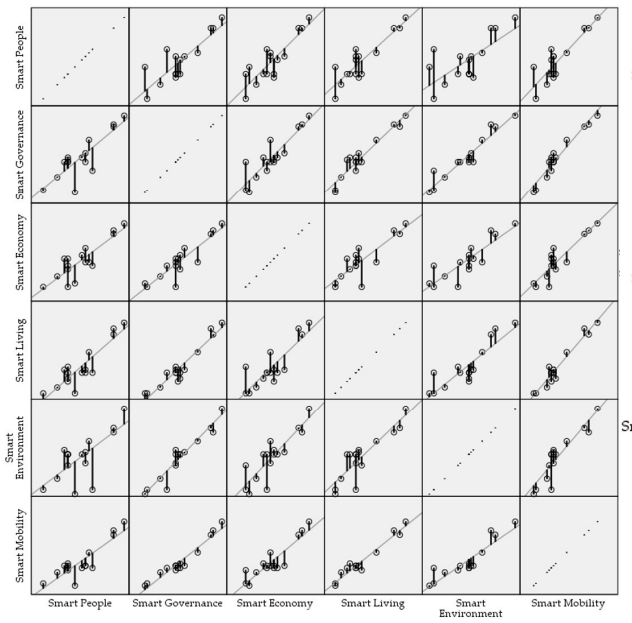
One-Sample Kolmogorov-Smirnov Test

		Smart People	Smart Governance	Smart Economy	Smart Living	Smart Environment
N		16	16	16	16	16
Normal Parameters[a,b]	Mean	62.75	51.19	66.50	61.00	47.88
	Std. Deviation	6.234	9.881	5.416	7.348	10.658
Most Extreme Differences	Absolute	0.164	0.195	0.151	0.250	0.167
	Positive	0.164	0.195	0.151	0.250	0.135
	Negative	−0.119	−0.162	−0.104	−0.120	−0.167
Kolmogorov-Smirnov Z		0.655	0.780	0.603	1.000	0.668
Asymp. Sig. (2-tailed)		0.784	0.577	0.860	0.270	0.763

a. Test distribution is Normal.
b. Calculated from data.

Values are higher than 0.05 which means that there is a normal distribution.

Figure A3. The results of One-Sample Kolmogorov–Smirnov Test to detect the normal distribution.



Smart Economy;Smart People: R^2 Linear = 0.741
Smart Living;Smart Mobility: R^2 Linear = 0.941
Smart Mobility;Smart Environment : R^2 Linear = 0.813
Smart Environment ;Smart Economy: R^2 Linear = 0.744
Smart Living;Smart Environment : R^2 Linear = 0.770
Smart Mobility;Smart Economy: R^2 Linear = 0.808
Smart Living;Smart Economy: R^2 Linear = 0.733
Smart Governance;Smart People: R^2 Linear = 0.709
Smart Economy;Smart Governance: R^2 Linear = 0.801
Smart People;Smart Governance: R^2 Linear = 0.709
Smart Economy;Smart Living: R^2 Linear = 0.733
Smart People;Smart Living: R^2 Linear = 0.793
Smart Economy;Smart Mobility: R^2 Linear = 0.808
Smart People;Smart Mobility: R^2 Linear = 0.762
Smart Economy;Smart Environment : R^2 Linear = 0.744
Smart People;Smart Environment : R^2 Linear = 0.501
Smart People;Smart Economy: R^2 Linear = 0.741
Smart Environment ;Smart People: R^2 Linear = 0.501
Smart Mobility;Smart People: R^2 Linear = 0.762
Smart Living;Smart People: R^2 Linear = 0.793
Smart Governance;Smart Living: R^2 Linear = 0.910
Smart Governance;Smart Mobility: R^2 Linear = 0.932
Smart Governance;Smart Environment : R^2 Linear = 0.911
Smart Governance;Smart Economy: R^2 Linear = 0.801

Figure A4. The scatterplot graphic of smart city dimensions and r^2 values to test the linear relationships.

Table A1. Review of the research aiming to evaluate the differentiations between smart cities.

Research	Main Scope/Focus	Case Study Scale	Methodology	Findings
[44]	To analyse how smart city development correlates with the socio-economic indicators.	OECD countries and key partners, grouped into four clusters (based on GDP per capita). Special focus on China and the USA.	Comparative study utilising cluster analysis.	- Countries with a higher socio-economic development level have more smart cities overall. - Asian countries, especially China, show the fastest growth rate in smart city development. - China's state-led digital transformation policies have significantly accelerated its smart city growth.
[45]	To evaluate the smart city development level of Salatiga, Indonesia, across smart city dimensions.	The city of Salatiga, a medium-sized city in Central Java, Indonesia.	Calculate scores for each smart city dimension in Cohen Smart City Wheel.	- Smart Environment, Smart People, and Smart Living are the most developed dimensions in Salatiga, whereas Smart Mobility and Smart Economy are the weakest dimensions due to the limited public transport tech integration and low R&D investment. - The study demonstrates how localised data-driven assessments can guide smarter urban policies.
[46]	To explore how geography, culture, strategy, and governance influence the development and implementation of smart city projects globally.	Regional scale with examples from the following areas: - Europe and North America - Latin America - East and South Asia	Qualitative conceptual analysis.	- Citizen-centric, technology-centric, and governance-centric models vary across regions due to cultural and socioeconomic contexts. - Europe and North America: innovation-driven, citizen-focused, and globally competitive. Latin America: socially focused, influenced by the Global North, with emerging models.East and South Asia: efficiency- and tech-driven, largely top-down, with surveillance concerns. - Governance approach matters: top-down enables speed, as in China and Singapore, but may limit participation; bottom-up enables inclusion, as in Milan and Copenhagen, but may slow implementation. - Calls for balanced hybrid models combining strong governance with community engagement.
[47]	To assess and compare the smartness levels of Brazilian state capital cities.	All 27 Brazilian capital cities, grouped into performance clusters: Leading, Following, and Developing.	Adapted a multi-dimensional, comprehensive smart city assessment model previously used in Australia.	- Leading cities have strong innovation ecosystems, smart policy, skilled labour, and better infrastructure. - Sustainability and accessibility and connectivity and innovation were weak points for most cities, even the top performers. - There is a clear regional divide: Southern/South-eastern cities perform better than Northern/North-eastern ones. - The framework can guide localised policy development and performance benchmarking.
[48]	To identify the spatial and socio-economic configurations that explain why some cities are more advanced than others in developing smart city initiatives.	22 cities in Switzerland with at least one smart city project.	Fuzzy-set Qualitative Comparative Analysis.	- A combination of high service sector employment, the presence of universities, and urban density is sufficient for greater smart city development. - City size and population growth are not key drivers in the Swiss context. - Smaller cities with strong service sectors and proximity to research institutions also performed well. - Knowledge economy and urban form are critical for smart innovation.
[49]	To analyse how smart city characteristics, influence urban attractiveness, measured by housing market prices.	103 Italian NUTS-3 province capitals.	OLS regression and K-means cluster analysis based on Giffinger et al.'s six-dimension smart city model.	- Smart Living, Smart Economy, and Smart People are the strongest predictors of urban attractiveness. Smart Environment had minimal influence on housing prices. - Cluster analysis revealed four types of cities: Competitive: strong across all dimensions; high housing prices. Attractive: good smartness levels; slightly lower than competitive. Liveable: medium cities with generally strong characteristics, except for higher unemployment. Specialising: small southern cities with weaker overall performance but some smart specialisation potential. - Geography matters, as Northern cities consistently outperformed Southern ones.
[50]	To develop a data-driven, reproducible ranking of the European Union capital cities based on how smart and sustainable they are.	All 28 European Union capital cities.	Hierarchical clustering, principal component analysis and correlation analysis, using the UNECE-ITU smart sustainable cities framework.	- Top cities: Berlin, Stockholm, Helsinki Lowest ranked: Sofia and Bucharest - Key success factors are wastewater treatment, bicycle infrastructure, patent applications. - No significant correlation with population size, but strong positive correlation with GDP per capita. - A clear East–West divide in performance, with Western/Nordic cities leading.
[51]	To evaluate and rank selected cities in terms of smart and sustainable city performance using a weighted, multi-criteria framework.	44 cities worldwide, selected from the Global Power City Index.	ANP (Analytic Network Process) and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution).	- Smart living had the highest priority among all dimensions; Smart governance the lowest. - Top-ranked cities: Tokyo, London, New York. However, those cities did not perform best in terms of the governance, mobility, or environmental dimensions, highlighting performance gaps. - The framework helps identify areas where cities need improvement, offering a comparative benchmarking for policy design.
[52]	To develop a robust evaluation framework to assess smart city performance across multiple dimensions, addressing the limitations of traditional indices.	17 cities worldwide.	PROMETHEE II, an MCDA (Multi-Criteria Decision Analysis).	- Top-ranked cities: Singapore and Copenhagen - New Delhi ranked lowest but showed strength in terms of mobility technologies and digital governance tools. - No dominant city across all pillars—performance varies by dimension. - PROMETHEE II produced robust and nuanced rankings, offering a more refined view than traditional indices. - Smart city performance is multi-dimensional, and comparative advantage varies widely.

Table A1. *Cont.*

Research	Main Scope/Focus	Case Study Scale	Methodology	Findings
[53]	To enhance traditional smart region ranking methodologies by introducing a relational dimension based on regional collaboration, focusing on how inter-regional ties influence smartness profiles.	266 NUTS-2 regions across EU28, with specific attention to Piedmont (Italy) as a test case.	PCA (Principal Component Analysis) to derive region-to-region distance matrices.	- The best-performing regions appear more isolated in traditional smartness rankings. - When collaboration data are included, regions like Piedmont shift closer to their high-performing peers. - The study shows that regional partnerships can positively influence smartness convergence. - A more relational and dynamic approach to smartness evaluation helps better identify capacity-building opportunities for lagging regions.
[54]	To analyse how specific technological factors influence the development of smart cities in Kazakhstan using spatial econometric techniques.	Cities in Kazakhstan.	SAR (Spatial Autoregressive Model).	- The slight negative spatial autocorrelation suggests minimal spatial spillover among neighbouring cities. - Emphasises the need to prioritise digital administrative services over just infrastructure upgrades. - Suggests customised, context-sensitive strategies for smart cities in developing economies like Kazakhstan.
[55]	To critically examine the smart city development in China through the case of Shenzhen, evaluating how it aligns with or diverges from international smart city paradigms.	Shenzhen, China—as a model for China's smart city development.	Mixed-method case study.	- China's smart city model is highly technology-centric, focused on infrastructure and digital innovation, often with limited attention to the social and environmental dimensions. - Shenzhen exemplifies a successful transformation into a knowledge economy, led by high-tech firms like Huawei and Tencent. - Smart city development is state-driven, with limited citizen participation, differing from more decentralised international approaches.
[56]	To explore how geography—specifically the Global North vs. Global South divide—influences smart city development.	135 cities (87 Global North; 48 Global South) that participated in IBM's Smarter Cities Challenge.	Quantitative and qualitative comparative analysis.	- Global North cities most often prioritised economic development, environment, and transport. - Global South cities focused more on administration, transport, and economic development, but often for revenue recovery and to catch up in terms of infrastructure. - Global South cities typically tackled fewer smart dimensions and faced greater infrastructure deficits. - Multidimensionality of smart city initiatives was limited in both hemispheres; IBM's original vision for holistic transformation was diluted in practice. - Smart solutions in the Global South often reflected pressing basic infrastructure or public service needs, rather than futuristic innovation.
[57]	To analyse top-ranked global smart cities and identify the key policies and characteristics that contribute to their smartness.	Comparative analysis of top smart cities globally using data from three main indices.	Qualitative analysis.	- Cities like Zurich, Singapore, London, and Oslo consistently topped the rankings due to their strong performance in digital governance, infrastructure, and citizen-centred services. - Smart city success is multi-dimensional, combining technology, sustainability, and public engagement. - Geographic diversity: Leading smart cities were found across Europe, Asia, and North America, showing the global reach of the smart city movement. - Different indices emphasise different dimensions (e.g., IMD is citizen-centric; IESE includes broader governance and international projection). - The research highlights the importance of governance models, adaptability (especially during COVID-19), and innovation policies in smart city success.
[58]	To investigate the relationship between smart cities, subjective well-being, and urban liveability, with a focus on whether smart city development enhances happiness and sustainability.	Global comparative analysis of 59 cities using three indices.	Linear and multiple regression analyses.	- A positive correlation was found between smartness and both subjective well-being and liveability. - Smart environment is the most significant predictor of happiness. - Structural factors (infrastructure) matter more for well-being than technological solutions. - Cities in the Global South often show optimism (high subjective well-being) despite low liveability, while some advanced smart cities rank low on happiness. - The study highlights the importance of context-sensitive planning and interdisciplinary approaches to align smart city strategies with human well-being and sustainability goals.
[59]	To examine global patterns and the key enablers of e-governance in smart cities by clustering cities based on governance indicators and analysing economic, social, political, and ICT-related factors.	68 smart cities from different countries and regions, one per country, based on the IMD Smart City Index 2023 data.	Cluster analysis and VAR/VEC modelling.	- Four governance clusters emerged: Cluster 1 (highest governance scores) to Cluster 4 (lowest). - The Human Development Index and Digital Quality of Life Index had the strongest positive effects on e-governance. - GNI per capita had no significant effect in any cluster. - The Democracy Index had mixed effects, being positive in high-income democracies but negative or neutral in others. - Some cities excel in e-governance despite their low democracy indicators—raising concerns about technocracy vs. democratic governance.

Table A2. Selected economic, social, and technological indicators * for the sub/intermediary regions.

	Economic							Social							Technological		
Continental Regions **Subregions** **Intermediary Regions**	**Population (000, 2024)**	**GDP: Gross Domestic Product (Million Current US$)**	**GDP Growth Rate (Annual %, 2015)**	**GDP Per Capita (Current US$)**	**Unemployment Rate (% of Labour Force)**	**Urban Population (% of Total Population, 2015)**	**Urban Population Growth Rate (Average Annual %, 2015)**	**Life Expectancy at Birth (Females, Years)**	**Life Expectancy at Birth (Males, Years)**	**Under Five Mortality Rate (Per 1000 Live Births)**	**Education: Upr. Sec. Gross Enrol. Ratio (f Per 100 Pop.)**	**Education: Upr. Sec. Gross Enrol. Ratio (m Per 100 Pop.)**	**Individuals Using the Internet (per 100 Inhabitants)**	**Research & Development Expenditure (% of GDP)**	**Researchers in Full Time Equivalent (Per Million, 2021) ****	**Patents Resident Filings (Per Million Population, 2022) ***
Africa	1,515,141	2,870,757	3.5	2014.8	6.6	41.2	3.7	66.1	62.0	62.4						16,200
Northern Africa	272,131	855,580	3	3298.4	11.3	51.4	2.3	74.6	70	26.9	69.9	64.6	69.3	0.7		
Sub-Saharan Africa	1,243,010	2,015,177	3.8	1729.1	5.8	38.8	4.1	64.4	60.3	67.6	33.6	38.3	37.0	0.3		
Eastern Africa	500,704	512,915	5	1087.4	4.3	26.6	4.6	68.6	63.1	48.5	33.6	38.3	29.7			
Middle Africa	212,916	287,184	4.1	1464.6	6.8	47.9	4.3	64.4	60.0	72.1			35.0			
Southern Africa	73,139	44,845	2.1	6484.7	27.6	62.1	2.3	69.5	62.6	33.6	33.6	38.3	75.9			
Western Africa	456,251	770,232	3.9	1795.1	3.3	44.5	4.3	59.4	57.5	89.2	33.6	38.3	39.9			
Asia	4,806,898	38,004,625	3.6	8048.6		48.0	2.4	77.4	72.3	25.8						1,226,700
Eastern Asia	1,656,115	25,047,265	2.4	15,063.0	4.7	59.8	2.4	82	76.1	7.7	92.1	89.3	79.2	2.7	2249.9	
South-Eastern Asia	695,149	3,630,588	5.6	5330.3	2.5	47.2	2.5	75.3	69.3	22.1	69.9	66.6	78.3	1.1	812.1	
Southern Asia	2,064,056	4,761,901	6.3	2372.0	5.1	34.5	2.5	73.8	70.3	33.3	62.9	65.9	50.5	0.6	311.2	
Western Asia	309,351	4,170,551	6.6	14,216.8	7.6	70.4	2.7	78.1	73.2	20.8	77.4	82.2	78.5	1.1	1215.4	
Central Asia	82,226	394,320	4.0	5118.4	4.6	48.1	1.7	76.1	69.4	16.6	87.2	88.3	81.3	0.1	471.5	
Oceania	46,089	2,080,031	3.1	46,473.3	3.7	68.1	1.5	81.6	77.1	18.2	115.5	117.0	78.5	1.7	3324.5	18,600
Australia & New Zealand	31,927	2,022,422	3	64,485.0	3.7	85.6	1.5	85.5	82	3.4	178	180	95.1	1.8	4695.9	
Melanesia	12,945	48,795	6.0	3930.9		19.2	2.2	69.8	64.7	35.5						
Micronesia	527	1304	0	4104.8		67.9	1.0	74.6	68.8	29.1			40.5			
Polynesia	690	7509	4.4	11,311.6		44.5	0.6	79.8	75.1	11.6						
Europe	745,084	23,858,902	3.0	32,000.5		73.9	0.3	82.7	75.9	4.1	110.1	109.8	91.6	2.0	3816.6	178,700
Eastern Europe	285,003	4,150,508	−0.2	14,330.6	4	69.3	0	79.8	70	5.1	110	110	91.6	2		
Northern Europe	108,964	5,652,647	4.3	53,207.2	5.4	81.4	0.9	83.6	79.5	3.7	110	110	91.6	2		
Southern Europe	151,254	4,226,047	4.7	27,853.1	9.4	70.6	0.2	85.1	80.2	3.4	110	110	91.6	2		
Western Europe	199,863	9,829,701	2.5	49,648.0	4.7	79.4	0.6	84.7	80	3.6	110	110	91.6	2		
The Americas	1,048,761	34,020,481	2.4	32,841.7	5.4		0.9	80.3	74.7	12.7						
Latin America & the Caribbean	663,466	6,127,970	4.0	9298.5	6.1	79.9	1.5	78.8	72.9	15.6	89.5	80.8	81.0	0.5	625.4	41,500
Caribbean	44,445	483,941	3.7	11,135.4	6.9	70.0	1.4	76.5	70.1	35.1			74.3			
Central America	183,410	1,785,939	4.2	9974.0	3.6	73.7	1.9	77.9	72.4	13.7	89.5	80.8	81			
South America	435,611	3,858,090	3.9	8838.5	7	83.5	1.3	79.3	73.5	14.4	89.5	80.8	81			
Northern America	385,295	27,892,511	2	74,012.0	4.2	81.6	1	82.3	77.4	5.8	101	100	97.3	3.3	4513.9	
World	8,161,973	100,834,796	3.1	12,647.1	6.0	53.9	2.0	76.0	70.7	36.0	69.2	70.2	67.4	1.9	1352.5	1,823,000

(*) All data pertaining to indicators, unless otherwise specified, were sourced from the "World Statistics Pocketbook 2024 edition" by UNSD [84]. (**) UNdata database, "Research and development (R&D) expenditure and researchers in full time Equivalent, year 2021" [83]. (***) UNdata database, "Patents Resident filings (per million population), grants and patents in force, year 2022" [83].

Table A3. Geographical distribution of cities in the SCI-2023 based on global regions.

Global Regions	Number of Smart Cities *	Number of Countries with Smart City * (B)	Number of Countries ** (C)	Share of Countries with Smart City (B/C%)
Global South	58	33	139	23.75
Global North	83	38	108	35.19

(*) The number of smart cities and the number of countries with smart cities were obtained from [60]. (**) The number of countries in the Global South was obtained from [81]. The number of countries in the Global North was calculated by subtracting the number of countries in the Global South from the total number of countries in the UNSD list [61]. The total number of countries in the UNSD list is 248; Antarctica was excluded from the calculations.

Table A4. Geographical distribution of cities in the SCI-2023 based on UNSD geographic regions.

Continental Regions Subregions Intermediary Regions	Number of Smart Cities *	Number of Countries with Smart City (A) *	Number of Countries (B) **	Share of Countries with Smart City (A/B%)
Africa	9	8	60	13.3
Northern Africa	4	4	7	57.1
Sub-Saharan Africa				
Eastern Africa	1	1	22	4.5
Middle Africa	-	-	9	0.0
Southern Africa	1	1	5	20.0
Western Africa	3	2	17	11.8
Asia	45	22	50	44.0
Eastern Asia	16	4	7	57.1
South-Eastern Asia	9	6	11	54.5
Southern Asia	5	2	9	22.2
Western Asia	15	10	18	55.6
Central Asia	-	-	5	0.0
Oceania	6	2	29	6.9
Australia & New Zealand	6	2	6	33.3
Melanesia	-	-	5	0.0
Micronesia	-	-	8	0.0
Polynesia	-	-	10	0.0
Europe	56	29	51	56.9
Eastern Europe	7	6	10	60.0
Northern Europe	19	11	16	68.8
Southern Europe	11	6	16	37.5
Western Europe	19	6	9	66.7
Americas	25	10	57	17.5
Latin America & the Caribbean				
Caribbean	-	-	28	0.0
Central America	3	5	8	37.5
South America	8	2	16	31.3
Northern America	14	2	5	40.0
Total/Average	141	71	247	28.7

(*) The number of smart cities and the number of countries with smart cities were obtained from [60]. (**) UNSD continental/sub/intermediary region breakdowns and the number of countries in respective regions were derived from [61]. The total number of countries in the UNSD list is 248; Antarctica was excluded from the calculations.

Table A5. Geographical distribution of cities in the SCI-2023 according to population groups.

Continental Regions Subregions Intermediary Regions	Classification of Cities According to Population Sizes *					
	Small Cities (100 k–500 k pop.)	Mid-Sized Cities (500 k–1 m pop.)	Large Cities (1 m–5 m pop.)	Metropolitan Cities (5 m–10 m pop.)	Megacities (10 m–20 m pop.)	Megacities More Than 20 m pop.
Africa	1	-	6	1	1	-
Northern Africa	1	-	2	1	-	-
Sub-Saharan Africa						
Eastern Africa	-	-	1	-	-	-
Southern Africa	-	-	1	-	-	-
Western Africa	-	-	2	-	1	-
Asia	1	2	19	10	9	4
Eastern Asia	-	-	4	6	4	2
South-Eastern Asia	-	-	5	2	2	-
Southern Asia	-	-	1	-	2	2
Western Asia	1	2	9	2	1	-
Oceania	1	1	4	-	-	-
Australia & New Zealand	1	1	4	-	-	-
Europe	6	27	22	1	-	-
Eastern Europe	-	2	5	-	-	-
Northern Europe	2	12	4	1	-	-
Southern Europe	1	5	5	-	-	-
Western Europe	3	8	8	-	-	-
Americas	-	8	9	4	2	2
Latin America & the Caribbean						
Central America	-	1	1	-	-	1
South America	-	-	2	3	2	1
Northern America	-	7	6	1	-	-
Total	9	38	60	16	12	6

(*) Population groups are classified considering [82].

Table A6. The difference between the smart city ratings and technology ratings of cities in the SCI-2023 at the sub/intermediary regional scale.

Intermediary Regions	Differences in Ratings *				Total Number of Cities
	−1.00	0.00	1.00	2.00	
Northern Africa	0	4	0	0	4
Eastern Africa	0	1	0	0	1
Southern Africa	0	1	0	0	1
Western Africa	1	2	0	0	3
Eastern Asia	3	12	1	0	16
South-Eastern Asia	1	8	0	0	9
Southern Asia	1	4	0	0	5
Western Asia	1	11	3	0	15
Australia & New Zealand	0	3	3	0	6
Eastern Europe	2	4	1	0	7
Northern Europe	3	8	6	2	19
Southern Europe	1	9	1	0	11
Western Europe	2	9	6	2	19
Central America	0	3	0	0	3
South America	2	6	0	0	8
Northern America	2	8	4	0	14
Total number of cities	19	93	25	4	141

(*) Differences in ratings are obtained by subtracting technology rating value from smart city rating value. Positive/negative values refer to higher/lower smartness levels than technological capacities.

Table A7. Geographical distribution of cities in the SCI-2023 according to smart city ranks.

Continental Regions Subregions Intermediary Regions	Max. Rank	Min. Rank	First 10	First 20	Last 20	Last 10	Total Cities
Africa	108	138	-	-	8	4	9
Northern Africa	108	137	-	-	-	-	4
Sub-Saharan Africa	125	138	-	-	4	2	5
Eastern Africa	131	131	-	-	1	-	1
Middle Africa	-	-	-	-	-	-	-
Southern Africa	125	125	-	-	1	-	1
Western Africa	132	138	-	-	2	2	3
Asia	7	140	1	6	3	3	45
Eastern Asia	12	98		3	-	-	16
South-Eastern Asia	7	115	1	1	-	-	9
Southern Asia	105	120	-	-	-	-	5
Western Asia	13	140	-	2	-	3	15
Central Asia	-	-	-	-	-	-	-
Oceania	3	31	1	2	-	-	6
Australia & New Zealand	3	21	1	2	-	-	6
Melanesia	-	-	-	-	-	-	-
Micronesia	-	-	-	-	-	-	-
Polynesia	-	-	-	-	-	-	-
Europe	1	122	8	12	1		56
Eastern Europe	14	111	-	1	-	-	7
Northern Europe	2	95	5	-	-	-	19
Southern Europe	27	122			1	-	11
Western Europe	1	101	3	6	-	-	19
Americas	21	141	-	-	8	3	25
Latin America & the Caribbean	118	141	-	-	5	3	11
Caribbean	-	-	-	-	-	-	-
Central America	121	141	-	-	-	1	3
South America	118	136	-	-	5	2	8
Northern America	21	98	-	-	-	-	14

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