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A Review of the Theory and Practice of Smart City Construction in China

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Abstract: The construction of smart cities is an imperative trend for high-quality urban development and represents a crucial solution to various problems that afflict urbanization, such as population growth pressure, resource scarcity, environmental degradation, and economic frailty. To create a smart city, it is essential to gain a profound understanding of the evolution and experiences of urban development and have a clear grasp of the concept, emphasis, and developmental trajectory of smart cities. However, previous research and theoretical frameworks have mainly focused on the digital transformation of cities, the application of new generation information technologies, and the comprehensive intelligence of cities, neglecting the fundamental positioning and value of cities, which is the people's central position and pursuit of happiness. This has led to many situations where intelligence is pursued for the sake of intelligence, resulting in inefficient use and allocation of resources. This paper puts forth a framework for the three generations of smart city construction and their meanings at the conceptual level, conducts an in-depth analysis of the development process and challenges of smart cities in China, and provides suggestions for improvement.

Keywords: China; smart city; theoretical development; practical exploration; review

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1. Introduction

Different cities have different cities' historical deposits, cultural traditions, social characteristics, economic bases, etc., making it challenging to propose a comprehensive and targeted theory or solution for smart city construction that considers the diverse construction situations in different locations. Moreover, research on the potential negative effects and issues associated with smart city construction remains relatively limited. China is the largest country and market for smart city construction in the world. Unlike developed countries, China's urban population continues to grow rapidly; the population's average education level is low; life is stressful, and many refined management initiatives that require popular participation or cooperation are difficult to implement, posing challenges for smart city construction. China's approach and progress in smart city construction presents a unique opportunity to observe and study the development of smart cities. It provides a natural laboratory for exploring the challenges and opportunities of smart city construction and can provide valuable insights for researchers and policy makers globally [1]. Current research on smart cities in China has focused on the policy implications [2], technological applications [3], construction effects [4], and development path [5], while insufficient consideration has been given to China's own unique urban–rural dual structure, large and concentrated urbanization, and rapid growth, among other factors [6]. Furthermore, significant public risks, such as the recent pandemic, have highlighted the need for enhanced emergency response and resilience in future smart cities. It is clear that the process of urbanization has a significant impact on the development of smart cities, and the strategies and solutions used to address the unique challenges faced by cities must evolve accordingly.

China has launched a smart city construction program over the past decade, and is at the forefront of smart city construction worldwide in terms of scale and speed of development [7,8]; however, there is a lack of theoretical research and support in the development of smart cities [9]. Despite the growth in smart city practice, there is a need to reflect on and summarize the progress of theoretical research and practical exploration. To address this, this article follows the logical progression underlying the theoretical and practical development of smart city construction in China. We delve further into the concept, elements, and structure of smart cities while improving the connotation of the concept of three generations of the smart city concept.

- Smart City 1.0: led by large technology-based companies, focused on technology development.
- Smart City 2.0: based on the Smart City 1.0, is led by the government and focuses on the role of technology as a tool, but the government's efforts are not always welcomed or accepted by the public. Most cities are built in the first or second generation.
- Smart City 3.0: based on the second generation, combines the "top-down" and "bottom-up" governance models, highlighting the people as the main body of smart city construction, and should promote participatory governance.

The Chinese context is also considered; the practical progress of smart cities is summarized and outlined; and the need for people-centric approaches that are adapted to local conditions and prioritized popular participation is emphasized. Ultimately, this article provides suggestions for the future development priorities of Chinese smart cities.

The structure of this paper is as follows. In Section 2, we introduce the theory, connotation, features, and evaluation system of the three generations of smart city construction. In Section 3, we summarize the global situation of smart city construction and its implications for China, providing important references for China's smart city construction. Section 4 starts from the characteristics of China's urban development, reviews the history and policy pilot of smart city construction in China. The guidance function of policies is crucial for urban development in China. In Section 5, we analyze the problems exposed in the current smart city construction in China and propose improvement suggestions. Finally, in Section 6, we conclude the paper.

2. The Theoretical Study of Smart Cities

2.1. The Connotation of the Concept of Smart City

The origin of the concept of a smart city can be traced back to the 1980s, when the New Urbanism movement emerged in the United States. This movement was accompanied by the introduction of information technology, and, in the 1990s, the term "smart city" was first used in the media [10]. In 2009, IBM CEO M.S. Peng proposed the concept of "Smart Earth", which aimed to realize a "sense, connect, and intelligence" core concept, leading to a significant increase in the popularity of smart cities worldwide [11,12]. The definition of smart cities varies across different countries and regions, due to varying economic, geographical, environmental, and cultural conditions, which has resulted in a lack of a unified understanding among the academic community. Although many scholars have attempted to outline the characteristics of smart cities, focusing on areas such as governance, technology, communication, sustainability, transportation, and environment, their definitions often lack universal recognition and have limitations. It is crucial to clarify the concept of smart cities in order to guide their actual construction, establish objective and feasible standards for evaluation, and build up a consensus. Achieving clarity is especially significant for addressing the challenges inherent to the global urbanization process. Scholars from various disciplines—including urban studies, computer and information technology, sociology, and public health—have proposed more than 30 different definitions, highlighting the need for further clarification [13]. Caragliu et al. offered a comprehensive and objective definition of smart cities as cities that invest in social and human capital, as well as traditional and modern communication infrastructure, and engage in participatory governance to promote sustainable economic and social development, improve the quality

of life of their citizens, and achieve the intelligent management of natural resources [14]. After synthesizing the theoretical and practical development of smart cities, the authors concluded that the concept and connotation of smart cities have undergone two significant iterations, as shown in Figure 1.

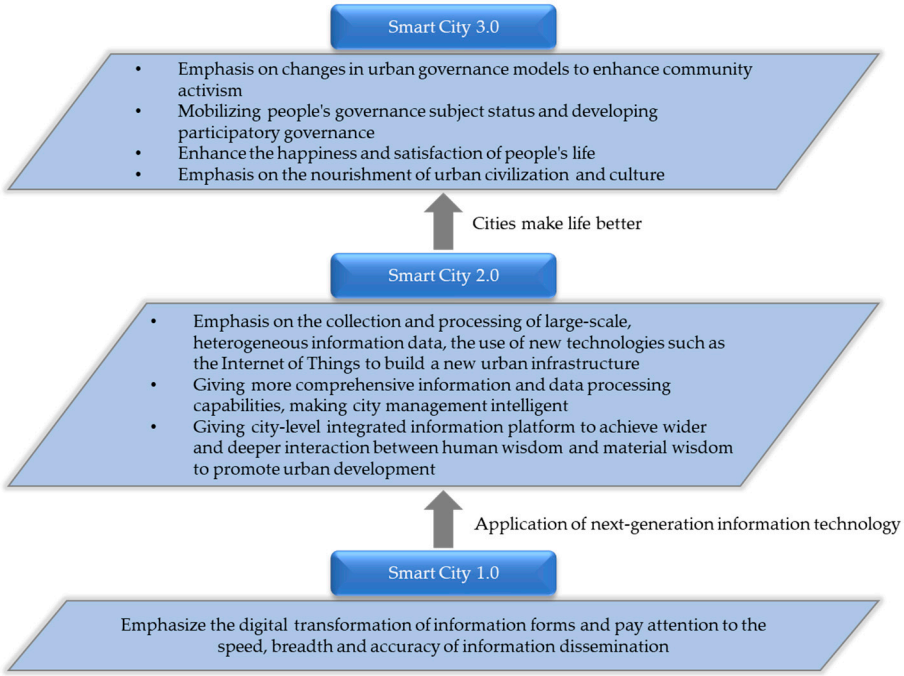

Figure 1. Comparison of the concepts of different generations of smart cities.

2.1.1. Smart City 1.0

The initial iteration of smart cities, centered on technology-centric approaches, was primarily aimed at enhancing urban development and operational models [15]. The first wave of smart cities was centered around the concept of utilizing new-generation information technologies, such as Internet of Things infrastructure, cloud computing, big data, and geospatial information integration, to promote intelligent urban planning, construction, management, and services. Such an approach primarily focuses on the role of technology in advancing urban development and construction [16]. Existing theories generally agree that large technology providers tend to play a leading role in the construction of smart cities at this stage, including IBM Corp [11], Songdo of the Republic of Korea [17–19], Portugal's PlanIT Valley [20,21], and China's Unicom [22,23]. The smart city operational model, which relies on IT support, data, and intelligent technologies, aims to upgrade industries, improve efficiency, and protect livelihoods. Regarding this stage of development, D.R. Lee [24] stated the representative view that a smart city is an intelligent digital city combined with the Internet of Things, which is essentially an intelligent urban management and operation mechanism that is visible, measurable, perceptible, analyzable, and controllable. The mechanism is established through comprehensive digitalization of the city's infrastructure, including sensors, networks, and computing resources, and utilizing a city information management and decision support platform that can analyze information and data in real-time [25].

With respect to this theoretical view, the development of smart cities has revealed several problems. For instance, Songdo, as a new technological city, has implemented various sustainable features such as green public spaces, efficient transportation, energy-saving buildings, sewage recycling, and waste management systems; however, despite these features, the quality of life of its residents remains unsatisfactory, the cost of living is high, and the city is far from achieving sustainable economic and social development. At present, the population of the city is only about 70,000, which is much lower than the original plan

to accommodate nearly 300,000 people. Matsushima is another example demonstrating the shortcomings of the first-generation smart city concept, which focused solely on high-tech hardware without considering the humanistic aspect of urban planning. Currently, Matsushima, which was initially intended as a business district, now resembles a high-end international residential area that falls short of meeting the expected targets. Thus, while high-tech hardware plays a crucial role in urban planning, it is equally important to prioritize humanistic aspects in city planning for long-term sustainable development.

2.1.2. Smart City 2.0

The second generation of smart cities adopts a more holistic approach to urban development, focusing on concept and vision rather than just technology [15]. Governments are often the main driving force behind this approach. Unlike the first-generation smart cities, which emphasized technological development, the governments of second-generation smart cities use high-tech devices, software, and platforms to address urban problems and enhance the quality of life of citizens. They also regulate the use of technology in order to prevent it from dominating city life or decision making [26]. Scholars, such as Trencher, have highlighted specific aspects of second-generation smart cities—such as addressing social issues, improving citizen well-being, optimizing public services, and prioritizing citizen needs—that are not necessarily technology-related [27]. A typical case here is Barcelona, Spain [28–31], where development has focused on green, livable, and sustainable aspects. Smart city scholars believe that the primary objective of building a smart city is to enhance the quality of life of its residents by addressing the mismatch between supply and demand that regulates the various functions of a city [32]. For example, Chinese scholar Li Chunjia [33] argued that the intellectualization of city citizens, the intelligence of technology, and the wisdom of the environment are the basic means and contents of urban development. Meanwhile, Myeong [34], Vukovic [35], and others consider the smart city as a comprehensive urban development strategy that integrates urban operation and management, industrial development, public services, and administrative effectiveness, culminating as a high-end form of modern urban development. Moreover, scholars stress that smart cities should prioritize sustainable development [36]. For example, Souza et al. contended that contemporary smart cities should prioritize sustainability and efficient management of energy, transportation, healthcare, and governance to cater to the demands of urbanization [37]. Similarly, Xu Qingrui et al. put forth a smart city framework with a pyramid-star structure and asserted that the objective and strategic goal of smart city development in China should revolve around achieving comprehensive and sustainable economic, social, and ecological progress, ultimately fulfilling the public's needs for security and well-being in life [38].

The prevalent definition of a smart city revolves around the concept of next-generation development. According to the International Organization for Standardization, a smart city is "an integrated built environment that effectively blends physical, digital, and human systems to provide its citizens with a sustainable, inclusive, and prosperous future" [39]. The Telecommunication Standardization Sector of the International Telecommunication Union highlights sustainable development and describes a smart sustainable city as an innovative urban center that leverages information and communication technologies and other resources to improve quality of life, optimize urban operations and services, enhance the competitiveness of the city, and meet the economic, social, environmental, and cultural requirements of both current and future generations [40]. In the Chinese context, the official definition of a smart city by the central government is encapsulated in the New Type of Smart City Evaluation Index. This index defines a smart city as an innovative urban center that harnesses information and communication technology to seamlessly integrate diverse urban management systems, foster information resource sharing and business synergy, promote intelligent urban management and services, enhance public services and urban operations, boost the happiness and contentment of city residents, and achieve sustainable development [41]. In comparison to the Chinese government, this

definition places a greater emphasis on clearly defining the objectives and tools of smart city development, prioritizing the application of new technologies such as ICT, emphasizing collaboration and resource sharing, and underscoring construction goals such as happiness and sustainable development for the benefit of the populace.

In summary, while there may be differences in the interpretation of smart cities among various scholars, institutions, enterprises, and cities, there are commonalities and overlaps in the underlying concept of a smart city system. The underlying concept is composed of people, data and information, digital technology (ICT), and physical systems [42]. The core principle of a smart city is the use of information technology to enhance wisdom in urban management and services. Smart infrastructure, public services, industrial systems, resource integration, security, and humanistic development comprise the primary content of a smart city, with the aim of achieving scientific development, efficient management, and a better quality of life for citizens [43]. Ultimately, the fundamental goal of smart city development is to address or mitigate the various issues confronting urban growth, optimize urban growth patterns, and enhance urban quality [44].

The Smart City 1.0 concept underscores the crucial role of emerging technologies in facilitating smart city development, which is an essential instrument for building smart cities. By contrast, Smart City 2.0 aims to differentiate itself from the previous iteration by placing greater emphasis on addressing urban challenges, enhancing public services, and improving the well-being of citizens. This new iteration recognizes the difference between the goals and tools of smart city construction, building upon the foundations of Smart City 1.0, and aims to promote a more holistic and comprehensive approach to smart city development.

2.1.3. Smart City 3.0

Based on the Smart City 2.0 concept, Smart City 3.0 pursues optimization of the way that urban groups are organized, highlighting the need for smart city construction paths to focus on participatory governance, to stimulate and bring the wisdom and power of the people into play, and to combine top–down and bottom–up approaches [15]. This iteration recognizes the limitations of Smart City 2.0, in terms of effective community feedback, and aims to promote more active citizen involvement in addressing urban challenges and shaping the future of their cities. Smart City 3.0 emphasizes the importance of inclusive decision-making processes, where citizens share their opinions and contribute to finding practical solutions to the social, environmental, and governance challenges of urban construction.

Central to the success of Smart City 3.0 is the concept of co-creation, which recognizes the vital roles of innovation and entrepreneurship in driving the construction and development of smart cities [15]. Smart City 3.0 construction requires the active participation of urban subjects to foster an innovative environment, promote inclusivity, and involve citizens in the problem-solving process for the city's development. This shift from passive service recipients to active co-creators of their own quality of life is essential. High-tech and popular innovation are the driving forces behind smart cities, and local demographic characteristics, geography, history, and culture should be considered in its development while adhering to the problem orientation.

In addition, there are many scholars who have sought to understand smart cities from the perspective of system theory. Scholars using system theory believe that modern cities are a class of open complex giant systems, such that their management presents the characteristics of dynamic non-linear complex giant systems with multiple dimensions, levels, structures, and intertwined and intricate sub-systems [45]. Some scholars in this field consider the smart city as a new urban ecosystem supported by new technologies covering citizens, enterprises, and governance, involving the digitally networked management of complex systems (e.g., urban geography, resources, ecology, environment, population, economy, and society) and the digitalization and informatization of all aspects related to the urban infrastructure and life development, according to the services and decision-

making functions of the information system. Xia and Wang [44] proposed that modern cities are complex systems that combine cyber, physical, and social systems. They define the "wisdom" of smart cities in terms of the integration of urban informatization, knowledge, creative city, sustainable development, and ecological livability. This definition goes beyond the perspective of information and communication technology, highlighting the importance of the interactions between the different systems [46,47].

The concept of a smart city has evolved from being tool-driven to target vision and realization pathways. Scholars have deepened their understanding and grasp of smart cities by considering various perspectives, including partial system theory. As the concept has been continuously analyzed and improved, the characteristics of smart cities have become increasingly clear.

2.2. Analysis of the Characteristics of Smart Cities

Urban morphology refers to the physical and cultural evolution of a city's external appearance. Over time, factors such as resource availability, initial level of development, external environment, economic structure, technology level, lifestyle, national psychology, and cultural characteristics contribute to the unique shape of a city, giving it dynamic, diverse, hierarchical, multidimensional, and structural characteristics. The smart city is an advanced form of urban development, with its core features shown in Figure 2.

Figure 2. Smart City Core Feature Diagram.

Smart City 1.0 is primarily concerned with digitizing information data. The goal is to integrate various types of data throughout the city, making it easier to share and use. This generation places greater emphasis on the digital conversion of information forms, allowing information to be disseminated more quickly, widely, and accurately through the network.

Building on the foundation of Smart City 1.0, Smart City 2.0 focuses on changing how information is collected and processed. Utilizing new-generation information technology such as the Internet of Things, cloud computing, big data processing, and intelligent analysis, the City Information Model is constructed that integrates urban planning, construction, management, and operation. The result is a more comprehensive and robust information processing capability, enabling intelligent production and manufacturing, urban management, and service operation. In addition, this version gives due attention to environmental factors such as humanities and institutions, changes in urban governance models, and the

expansion of smart technology applications in urban social fields, as well as the integration among urban systems.

Smart City 3.0 prioritizes people-centered cities as its core value. The concept of smart city construction must return to the root of urban services to increase residents' sense of access, happiness, and security. By expanding public participation, streamlining government scale, and empowering people's urban subject status, this generation aims to promote the innovation of the urban civilization paradigm. Future smart city construction should encourage the public's wide participation as it is an objective need for the economic development and social progress of the city. Additionally, this is an essential requirement for the city to improve its competitiveness and attractiveness.

2.3. Evaluation Index of Smart City Development

The advancement of smart city construction requires a set of authoritative evaluation index systems to guide the process. A unified evaluation index system lays a solid foundation for realizing massive multi-source heterogeneous data and achieving cross-sectoral integration applications. Technical elements must be constructed to meet evaluation criteria. Currently, many evaluation metric systems are proposed worldwide from different perspectives. For instance, IBM's smart city model proposes three main systems, including planning and management services, infrastructure services, and human services, each including three subsystems [48]. Similarly, Giffinger and Gudrun have identified 6 evaluation dimensions and 31 aspects, along with 74 indicators, in order to assess European smart cities in the economy, governance, environment, people, mobility, and life domains [49]. Marsal-Llacuna et al. argued that smart city construction progress requires real-time data-based monitoring indicators and proposed constructing a final synthetic index using a principal component analysis (PCA) approach [50]. In the Chinese context, the smart city criteria system includes 5 major categories of criteria divided into 4 levels, 16 technical areas, and 101 branches [51]. Some scholars have used specific city construction examples to develop city construction evaluation systems based on infrastructure fields, industry fields, government services, and cultural characteristics [52,53].

Overall, different evaluation index systems examine different directions, but indexes are selected based on the examination of digital transformation of data, integration processing and application of data, innovation, and application of new technologies in important areas of the city. These systems correspond to the construction characteristics of Smart City 1.0 and 2.0 stages but lack assessment of participatory governance and improvement of people's living standards. Recently, the Smart City Index evaluation system proposed by IMD has begun to focus on the feedback of the public on the construction situation, indicating a trend towards transition from Smart City 2.0 to 3.0.

Additionally, the construction of the evaluation index system should also consider the specific stage in which the city is developing. Some cities propose targeted evaluation systems based on their own development stages and characteristics. For instance, the European Smart Cities website introduces a European smart city model by analyzing indicators extracted from more than 90 smart city projects in Europe, and divides the model into sub-models reflecting small and medium-sized cities and large cities [54]. Furthermore, Cohen [55] put forward a comprehensive set of 18 measurement indicators and 46 sub-indicators based on 6 key elements. These categories cover all of the essential aspects of smart city indicators, making it one of the most comprehensive classification systems in the related literature.

As the study of smart cities in China has progressed, the evaluation system has undergone gradual improvements through the acquisition of relevant knowledge and exploration. In the current Chinese context, the smart city evaluation system consists of a set of scientific and systematic evaluation indicators that enable quantitative calculation and scientific evaluation of smart city construction results (see Figure 3).

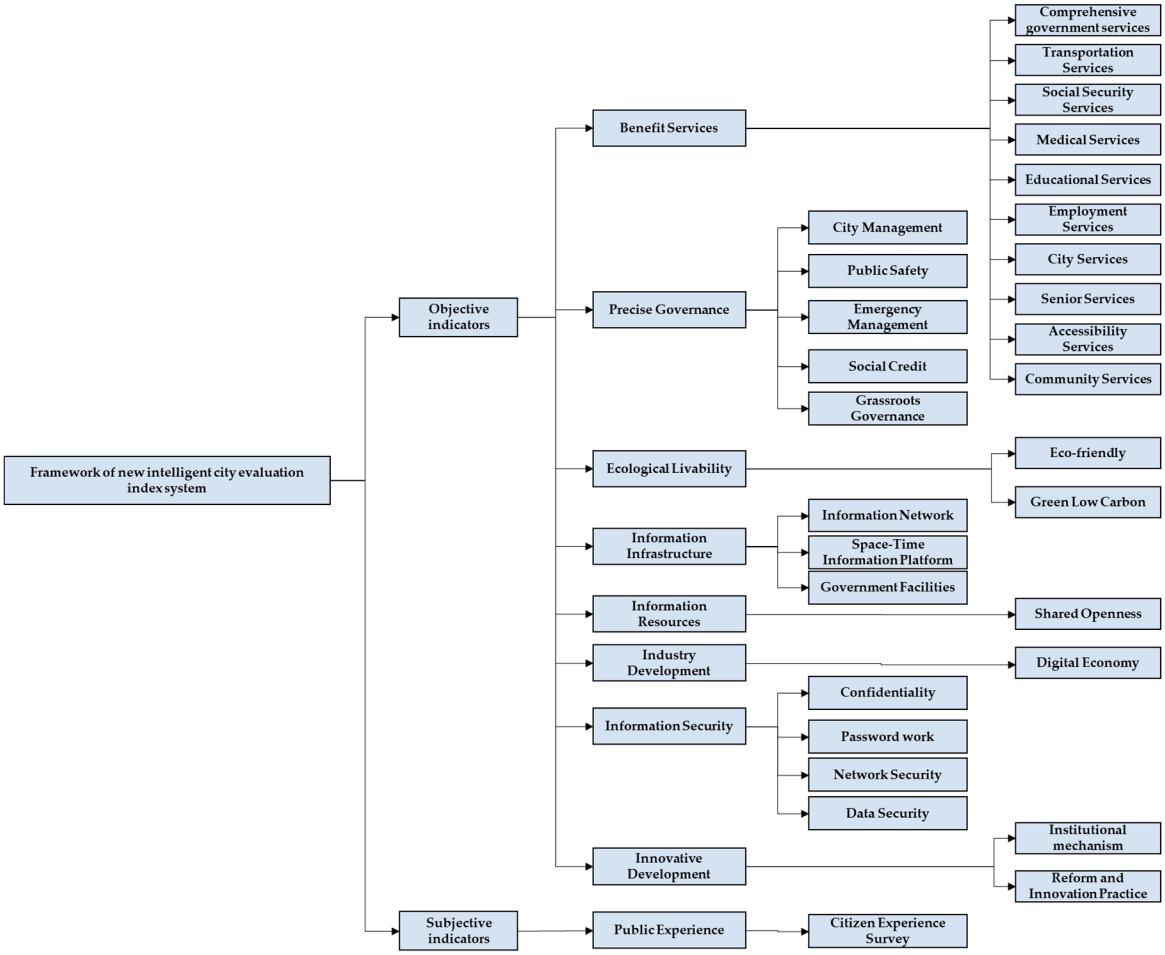

Figure 3. Framework of new smart city evaluation index system [41].

Since 2009, China has focused on the research and development of smart city construction standards; however, the country still lacks a third-party organization for standardization. In 2014, the Standardization Committee issued a notice regarding the establishment of the National Smart City Standardization Coordination and Promotion Group, along with the General Group and the Expert Advisory Group. The National Smart City Standardization General Group is the first official organization for standardization of smart cities in China, which is responsible for formulating the framework of China's smart city standardization system, standard development, strategy promotion, technical content, and application implementation of the standard at the national level. Meanwhile, local governments have also been exploring local standards that can guide their practices. For instance, Zhejiang Province, Shanghai City, and Guizhou Province have prepared the "Government Data Classification and Grading Guide (for trial implementation)" and the "Government Data Resources Catalogue" [56], which include metadata, core data elements, and compilation guidelines. These require city managers to systematically organize data types and business processes for standardization [57]. Despite some progress in standardizing smart city construction, it remains a complex project involving multiple industrial fields and city construction. Therefore, there is an urgent need to provide a collaborative platform for standardized knowledge services, project supervision, project management, standard testing, performance evaluation, and standard application demonstration.

3. The Construction and Inspiration of Smart Cities around the World

In order to have a comprehensive understanding of the current smart city construction, the keywords of "Smart Cities" and "Smart City" were searched through Web of Science,

Scopus, and Engineering Villages database, and the relevant documents and work reports were researched from the official government website. Based on the Web of Science database search, the number of published articles on the theme of smart cities from 2009 to 2022 is shown in Figure 4. We conducted a statistical analysis of cities ranked in the top 30 of the IMD Smart City Index from 2019 to 2023 [58], as shown in Table 1. The IMD Smart City Index focuses on analyzing the scope and impact of urban intelligence from a citizen's perspective. We believe that these cities, which were selected, can represent the advanced level of smart city development in the world today. We conducted a comparative analysis of the cities mentioned above and a few other classic city cases, focusing on economic development, citizen participation and experience, environment, mobility, governance, and living.

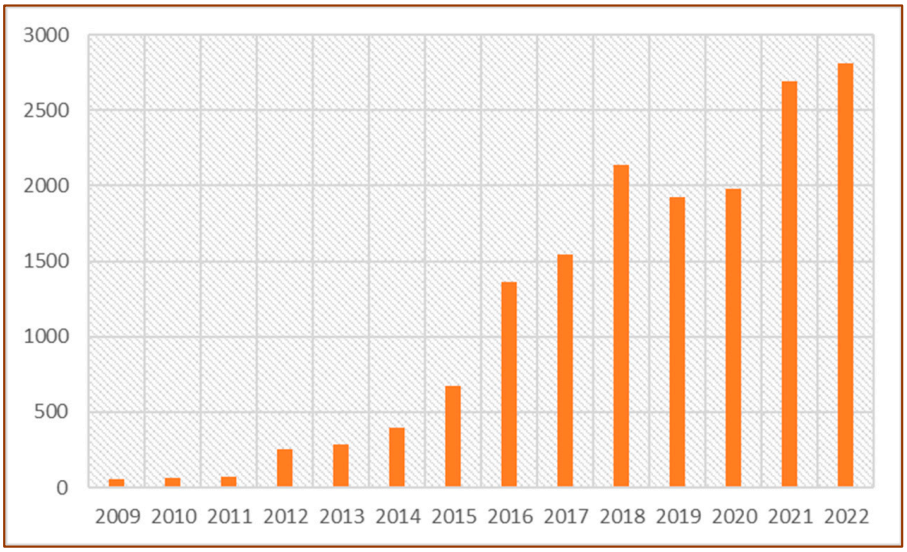

Figure 4. Number of published articles on the theme of smart cities from 2009 to 2022.

Table 1. Cities ranked in the top 30 of the IMD Smart City Index from 2019 to 2023.

City	City HDI	Rankings			
		2019	2020	2021	2023
Zurich	0.989	1	1	1	1
Oslo	0.98	2	2	2	2
Copenhagen	0.967	4	3	5	4
London	0.973	3	10	3	6
Singapore	0.939	10	7	7	7
Helsinki	0.96	6	5	9	8
Geneva	0.966	7	8	6	9
Stockholm	0.972	9	9	11	10
Beijing	0.907	30	22	17	12
Abu Dhabi	0.911	16	14	12	13
Prague	0.96	8	4	10	14
Amsterdam	0.962	11	11	13	15
Seoul	0.952	23	20	18	16
Dubai	0.911	13	19	14	17
Auckland	0.951	5	15	16	22
Bilbao	0.932	18	25	23	27
Vienna	0.942	12	18	20	28
Taipei City	0.916	24	23	25	29

Note: City HDI refers to the City Human Development Index and is an indicator used by the United Nations Development Program to measure the level of human development in cities. The higher the value is, the higher the level of human development is.

3.1. Smart City Construction Situation Worldwide

Many cities worldwide are facing infrastructure and service challenges due to population growth. As a result, traditional urban development models are no longer sufficient, and many cities have launched smart city development programs to enhance the quality of life of their citizens. Such cities include London, Stockholm, Dubai, New York, Barcelona, Hong Kong, Amsterdam, Singapore, Tokyo, Paris, and Copenhagen. However, the definitions of a smart city are inconsistent, due to distinct environmental, governance, and resource issues in each city. Some smart city definitions focus on sustainability or democracy; others emphasize data structure or organization, while some focus on smart infrastructure or transportation.

For example, smart city development in foreign countries typically focuses on smart living, smart economy, smart governance, smart environment, smart power, smart communications, and smart transportation. The US has prioritized smart city construction at a national strategic level, investing in infrastructure and smart grids. Europe, on the other hand, has focused more on improving energy use efficiency. Japan's i-Japan strategy aims to establish citizen-driven digital cities that foster trust and vitality, while Singapore's "Smart Nation 2015" plan has launched numerous projects to create a smarter city of the future.

Smart city exploration and construction are not limited to developed countries, as many developing countries are also actively involved in this field. Developing countries face faster urbanization rates and greater infrastructure challenges. For example, in 2014, India announced its intention to construct over 100 smart cities with high-tech communication capabilities. South Korea's National Strategic Smart City Program (NSSP) has established a new technological ecosystem and standards for smart cities. NSSP services leverage 5G telecommunication technologies and data structures, with the aim of expanding the industrial landscape of smart cities. Yang et al. have described the NSSP's smart city services and compared them with those offered by 15 smart cities in Europe, Asia, and North America [59].

Numerous scholars have analyzed the global development of smart cities from diverse perspectives. Angelidou compared and evaluated various smart city development strategies, identified their advantages and disadvantages, and provided recommendations [60]. Lee et al. conducted an empirical study on smart city construction in San Francisco and Seoul, revealing that effective and sustainable smart cities require dynamic coordination between managers and citizens on an open innovation platform. They also identified the need for complementary linkages among various participants, which should be adjusted according to the stage of urban development, social culture, and governance capacity [61].

Countries tend to adopt two primary models for smart city construction: Top–down technology-led models for new city construction, and a model that combines bottom–up and top–down approaches to encourage innovative services in established cities, based on relevant development needs. For instance, the Masdar Smart City project in the UAE, initiated in 2006, seeks to leverage solar technology to create a zero-carbon, sustainable, and smart habitat to house 50,000 people, 1500 clean technology firms, and employ 60,000 people daily. Despite some smart and traditional technological measures, such as smart wind towers, shade shelters, and shade connections, the city's economic and operational sustainability has not been well-addressed. The high cost of living associated with this urban construction model limits social integration and the heavily invested driverless bus system does not meet daily travel needs of residents. Additionally, local sand and dust issues severely impact the efficiency of solar panels. Thus, the lack of sustainability in Masdar's smart city project has become a significant challenge.

The Songdo smart city project in South Korea was awarded the 2008 Sustainability Award for being the most advanced new large-scale smart city construction project. However, it followed a top–down, supply-oriented construction model that focused more on physical hardware and industrial benefits, leading to huge financial investments and increased investment risk for the public sector, thus deviating from the knowledge culture starting point. The needs of local communities were ignored, public participation was

lacking, and the ecological footprint increased, posing potential problems for future development.

On the other hand, the Amsterdam Smart City project, which began construction in 2009, is not technology-led but, rather, encourages the application of innovative technologies by multiple actors, promoting behavioral change among end-users. It emphasizes a quadruple helix partnership of government, business, academia, and community, engaging local communities in a bottom–up approach through the Smart City Living Lab to provide solutions for the city and its residents, ultimately combining environmental and social development goals with economics and technology. Similarly, Brisbane, Australia, has been successful in developing a knowledge corridor and upgrading public transport services to the city center.

Overall, the development of smart cities is still in its infancy, and technology alone cannot facilitate the complete construction and operation of a smart city. Smart decisions and policies that integrate smart city construction into a sustainable urban development framework with the quadruple bottom line of economic, social, environmental, and governance are necessary. The wisdom of citizens and communities is also critical in improving the efficiency of cities.

3.2. The World's Smart City Construction to China's Inspiration

The global construction of smart cities reflects the city's evolution in terms of material form and cultural connotation. This evolution has been shaped by a range of factors, including resource endowment, initial level, external environment, economic structure, technology level, lifestyle, national psychology, and cultural characteristics.

The development of new-generation information technology has had a direct impact on the operation of cities. The digitalization of various information data has significantly increased the speed, breadth, and accuracy of information transfer, people flow, and material exchange, thereby upgrading the city's operation system. The resultant improvement in operational efficiency has led to changes in the institutional and organizational systems that ensure the city's smooth functioning, creating a society in which everything is interconnected. This has led to the development of intelligent transportation, governance, medical care, energy, and other areas, thereby enhancing the city's wisdom. The ultimate goal of this wisdom is to serve the quality of life of people in the city by providing convenience and enhancing community activity, using smart technology to realize the fundamental purpose of the city, which is to make life better and innovate the paradigm of urban civilization. Figure 5 illustrates the logical progression model of the city's evolution. The model consists of two main parts, top–down (TD) and bottom–up (BU). TD means that the city's value system and relationship system guide the construction, development and operation of the city, while BU means that the city's institutional and organizational system will play a modifying role in influencing the city's value pursuit and relationships within the city.

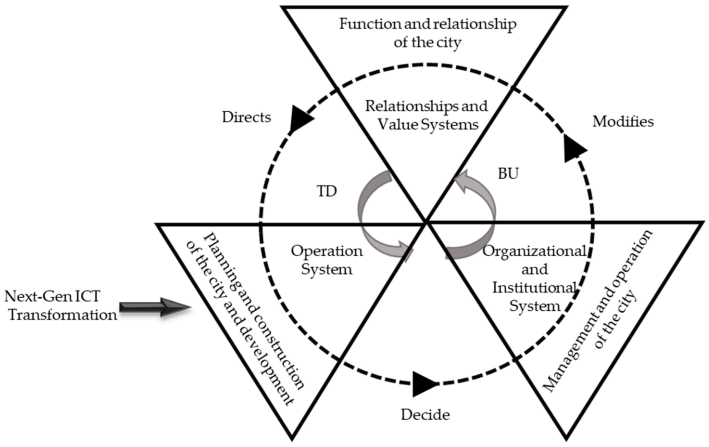

Figure 5. The logical progression model of the city's evolution.

The agglomeration of people is at the heart of urban development, and the relationship between individuals and groups and the relationship and interaction between people and nature constitute the deep structure of cities. Therefore, the deep development of cities requires the discovery and promotion of urban civilization and culture, the construction of both material and spiritual civilization, and the promotion of participatory governance.

Lan H. [62] identified three main challenges of urbanization: urban planning, construction, and development; urban management and operation; and urban functions. These challenges correspond to the three generations of smart city concepts, and the construction of smart cities worldwide provides valuable experience for China to address these problems. As cities experience rapid population growth, resource constraints, environmental pollution, and traffic congestion, smart cities with new-generation information technology provide a solution to these problems by promoting digital transformation, enhancing the speed and accuracy of information transmission, and improving infrastructure innovation.

The construction of Smart City 1.0 has realized the digital transformation and upgrading of the city, laying an essential foundation for the comprehensive transformation of urban governance, industry, development, and environment.

The development of Smart City 2.0 involves the integration and application of heterogeneous, large-scale data from various industries and intelligent technologies in different aspects and levels of urban governance. However, the ultimate goal of city construction is not only integrated and comprehensive intelligent development but also the agglomeration of people and the relationship and interaction between people and nature, which form the deep structure of cities. Therefore, promoting participatory governance and discovering and promoting urban civilization, culture, and characteristics are critical for the deep development of the city.

The development of Smart City 3.0 represents a new stage of urban civilization, which is to build a harmonious and livable city—that is, to create a city that is more compatible with the laws of nature, human society, and human development. The development of Smart City 3.0 is based on the integration and innovation of urban governance, industry, ecology, and civilization, and the construction of an organic and healthy symbiosis system that can adapt to the laws of nature, human society, and human development and realize the sustainable development of cities. Smart City 3.0 focuses on improving the overall quality of human life, emphasizing people-oriented, ecological harmony, and social governance, and promoting the harmony between man and nature, people and society, and people and people. Therefore, the construction of smart cities should take the people as the center and the harmonious development of human and nature as the goal, not only pursuing the intelligence of the city but also paying attention to the livability, cultural heritage, and ecological environment of the city.

4. Policy Development and Practice of Smart Cities in China

4.1. Characteristics of China's Urban Development

Since the promotion of the concept of smart cities in China, the development of Chinese cities has undergone many changes. The development concept of Chinese cities has shifted from emphasizing development as the top priority and achieving comprehensive, coordinated and sustainable development to building smart, livable and resilient cities. The people-oriented concept has always been upheld, with increasing attention paid to environmental protection, livability, and the quality of people's lives.

From the perspective of urban development strategy, Chinese urban development has evolved from the "point-driven" development model with special economic zones, new areas, and industrial parks as carriers to the "surface-driven" development model with comprehensive supporting reform pilot zones as carriers, and has now formed a trend of "19 + 2" urban clusters, transitioning from institutional reform to dual evolution of institutional and development modes. However, there is still uneven development among regions, and resource allocation needs to be tilted towards small and medium-sized cities.

In terms of urban governance, China has achieved breakthroughs in legal construction and policy-making at the level of city planning, urban land management, urban economic management, urban employment management, and urban environmental construction. A series of new policies and regulations have been introduced to solidify the foundation for the transformation of cities from extensive to intensive development.

In terms of urban development mode, the focus has shifted from solely pursuing economic efficiency to simultaneously paying attention to social development and improving people's quality of life. The development mode has gradually shifted from focusing on external expansion to improving the internal quality of cities. In particular, after the release of China's 14th Five-Year Plan, high-quality urban development has become a consensus. With the vigorous development of new-generation information technology, urban development is showing accelerated integration of industrialization, informatization, and urbanization. Concentrated urbanization, the construction of large urban clusters, and dispersed urbanization are all advancing at the same time, while urbanization and rural-urban integration are also advancing simultaneously. The coordinated development of large, medium, and small cities and small towns has become a new feature.

The current characteristics of smart city construction in China are significant differences in regional development. The market size of smart city construction is enormous, with over 900 cities at or above the prefecture level having smart city construction plans that have entered the implementation stage, and smart cities are extending upstream and downstream to smart city clusters and county-level smart city construction. Compared with the eastern region, the population size and density of Chinese cities in the central and western regions are vast. They hope to achieve common prosperity, material civilization, and spiritual civilization through smart city construction, and harmony between people and nature.

4.2. The Development Process of China's Smart Cities

The development of smart cities in China is unique due to the country's special national conditions, including a large population base, urban–rural dual structure, urbanization concentration, and continued rapid growth. China's smart city construction has gone through four stages of policy promotion.

The first phase of smart city development is the exploration and development period, marked by the Smart City 1.0 stage. From the end of 2008 to August 2014, the concept of "Smart Earth" proposed by IBM quickly spread worldwide and gained widespread recognition, resulting in a surge in smart city construction globally. China also began to explore smart city construction independently during this period. However, compared to other countries, China's smart city practice was relatively late. At that time, exploration lacked top-level design and coordination, and development showed a free trend, relatively scattered and disorderly. In 2010, relevant national ministries and commissions mainly guided pilot work in their own scope, while cities mainly promoted the idea of digital city construction. Cities such as Shenzhen, Ningbo, Foshan, Yangzhou, Nanjing, Shanghai, Beijing, and others joined the ranks of smart city construction. In early 2013, the Ministry of Housing and Construction announced the pilot list of the first 90 national smart cities and promulgated the Interim Management Measures of National Smart City Pilot and the National Smart City Pilot Index System, which kicked off the prelude to the comprehensive construction of smart cities in China.

The second stage of smart city development is characterized by standardization and integration and marks a transition from Smart City 1.0 to 2.0. The first phase of free development resulted in inconsistencies and challenges such as information silos, inadequate top-level design, and low-level duplication of construction. Between August 2014 and December 2015, the National Development and Reform Commission and seven other ministries and commissions issued the "Guidance on Promoting the Healthy Development of Smart Cities", which was the first systematic document approved by the State Council to comprehensively guide the construction of smart cities in China. This initiative resulted

in the formation of an "Inter-ministerial Coordination Working Group for Promoting the Healthy Development of Smart Cities" at the national level, led by the National Development and Reform Commission and comprising 25 ministries. Various departments are now collaborating to guide the construction of local smart cities.

The third stage can be characterized as the strategic upgrading period that marks the transition to Smart City 2.0. During the period spanning from December 2015 to December 2017, the Central Urban Work Conference was held in 2015 [63], which represents a significant turning point. At the conference, smart cities were given greater attention and elevated to the national strategic level, emerging as a crucial aspect of the country's new urbanization plans. Following this, a new concept of smart city was proposed, with a greater emphasis on the comprehensive development and application of new-generation information technology in various fields of urban management, aimed at achieving sustainable urban development and enhancing the comprehensive competitiveness of cities. This new concept marks a shift towards Smart City 2.0.

The fourth stage is the period of deepening development, in which the exploration of Smart City 3.0 begins in terms of development concepts and planning. In October 2017, the 19th Congress of the Communist Party of China proposed the key construction of a smart society, after which the construction of new smart cities accelerated and formed the "19 + 2" smart city cluster development trend, gradually extending construction achievements to districts, counties, and rural areas. In this stage, relationships between people, nature, and cities are deeply explored, and the improvement of people's quality of life and participatory governance are emphasized as goals of urban development. The pursuit of urban construction values and innovation of civilization paradigms are highlighted, and the construction of smart cities is becoming increasingly mature.

Overall, the development of smart cities in China plays a significant role in achieving sustainable urban development, through leading the application of information technology, enhancing the comprehensive competitiveness of cities, and improving the quality of life of residents. As such, it is a key transformation direction for urban development in China.

4.3. Relevant Support Policies and Pilot Work

Policy support plays a crucial role in promoting the development of smart cities. In order to guide and ensure the healthy and sustainable development of smart cities, the State Council and various ministries have issued multiple documents and guidelines related to smart city construction in recent years (see Table 2).

Table 2. Key policies related to the construction of smart cities.

Release Time	Send a Message Unit	Policy Name	Core Content of the Document about Smart Cities
2012	State Department	The State Council on vigorously promote the development of information technology and effective protection of information security of a number of opinions	Promote the sharing of urban management information, promote the grid management model, accelerate the implementation of smart grid, intelligent transportation, and other pilot demonstrations to guide the healthy development of smart city construction
2012	Ministry of Housing and Construction	National Smart City Pilot Interim Management Measures" "National Smart City (District, Town) Pilot Index System (for trial implementation)	Regulating and promoting the healthy development of smart cities
2014	The Central Committee of the Communist Party of China and the State Council	National New Urbanization Plan (2014–2020)	Explicitly request to promote the construction of smart cities and put forward the main points to promote the construction of smart cities

Table 2. *Cont.*

Release Time	Send a Message Unit	Policy Name	Core Content of the Document about Smart Cities
2014	National Development and Reform Commission and other 8 ministries	Guidance on promoting the healthy development of smart cities	Clearly put forward the development ideas of China's smart cities, construction principles, major goals, and information security requirements, in order to strengthen guidance of the construction of smart cities around the practice
2015	National Standards Committee, Central Internet Information Office, National Development and Reform Commission	Guidance on the Construction and Implementation of Smart City Standard System and Evaluation Index System	Accelerate the development of relevant standards, ensure that the development of standardization of smart cities is officially on the national agenda
2016	State Department	"Thirteenth Five-Year Plan" National Informatization Plan	Proposed to build 100 new model smart cities by 2018; by 2020, the construction of new smart cities to achieve remarkable results
2016	The Central Committee of the Communist Party of China and the State Council	Further strengthen the management of urban planning and construction of a number of views	Strengthen the intelligent construction of urban management and service systems, promote the integration of modern information technology and urban management services, and enhance urban governance and services; strengthen the construction and functional integration of digital platforms for urban management
2017	National Bureau of Surveying, Mapping and Geographic·Information	Technical Outline for the Construction of Spatio-temporal Big Data and Cloud Platform for Smart Cities (2017 Edition)	Relying on the city cloud support environment, realize the promotion of space–time benchmark, big data, and information cloud platforms for smart cities, build urban space–time infrastructure and develop smart city thematic application systems
2017	Ministry of Transportation and Communications	Smart Transportation for Easier Travel Action Plan (2017–2020)	Accelerate the development of intelligent urban transportation travel
2017	Central Internet Information Office, etc.	Notice on the implementation of the national e-government comprehensive pilot	By the end of 2019, the pilot areas of e-government coordination capacity should be significantly enhanced, the level of infrastructure intensification significantly improved, the basic realization of the orderly sharing of government information resources on demand
2017	State Department	New Generation Artificial Intelligence Development Plan	Promote intelligent social governance
2017	Ministry of Industry and Information Technology	Notice on the comprehensive promotion of mobile Internet of Things (NB-IoT) construction and development	From 3 aspects, take 14 measures to comprehensively promote the development of mobile Internet of things construction
2018	General Administration of Market Supervision, etc.	Smart City Top Level Design Guide	Gives the general principles of the top-level design of the smart city, the basic process and the specific construction of demand analysis, overall design, architecture design, and implementation path planning
2019	National Development and Reform Commission	Key tasks of new urbanization construction in 2019; security assessment methods for cloud computing services	Clarify the key tasks of the current phase of urbanization, improve the security and controllability of the procurement and use of cloud computing services by party and government organs and operators of critical information infrastructure

Table 2. *Cont.*

Release Time	Send a Message Unit	Policy Name	Core Content of the Document about Smart Cities
2019	Ministry of Natural Resources	Smart City Spatio-temporal Big Data Platform Construction Technology Outline	Building a pilot space–time data platform for smart cities, guiding the construction of space–time data platforms and encouraging intelligent applications
2019	The Central Committee of the Communist Party of China and the State Council	Outline of the Development Plan of Guangdong, Hong Kong and Macao Greater Bay Area	Emphasis on promoting the pilot demonstration of a new type of smart city and the construction of a national big data comprehensive pilot area in the Pearl River Delta region
2020	National Development and Reform Commission	New urbanization construction and urban-rural integration development tasks in 2020	Implementation of a new type of smart city West East, improve the digital management platform and perception system, open up the community end, integrate information systems and data resources in various fields to support rapid response to emergencies
2021	National People's Congress	Outline of the Fourteenth Five-Year Plan and Vision 2035 for National Economic and Social Development of the People's Republic of China	Grading and classification to promote the construction of new intelligent cities
2022	Central Committee of the Communist Party of China	Report at the 20th National Congress of the Communist Party of China	Accelerate the transformation of the development of megacities, implement urban renewal actions, strengthen urban infrastructure construction, and build livable, resilient, and smart cities

Since 2010, the Development and Reform Commission, the Ministry of Housing and Construction, the Ministry of Industry and Information Technology, the Chinese Academy of Engineering, the Ministry of Science and Technology, the National Standards Committee, the National Bureau of Mapping and Geographic Information, and other relevant ministries and bureaus have conducted pilot smart city projects in areas where suitable conditions exist, in order to actively explore and accumulate valuable experience. As of 2022, a total of 14 provinces, municipalities, and autonomous regions in China, including Beijing, Shanghai, and Hebei, have released guidance or development plans to promote the construction of new smart cities. Additionally, 24 provincial, municipal, and autonomous regional governments, as well as several prefecture-level cities such as Qingdao, Shenzhen, and Ningbo, have issued guidance and development plans regarding the "digital economy". Liu, Peng et al. have categorized China's pilot smart city construction into three main application areas and their subfields: enhancing quality of life (e.g., family, community, healthcare, and education); improving public management and services (e.g., public safety regulation, food safety regulation, smart transportation, smart tourism, and environmental protection); and broad resource management (e.g., water, electricity, and agriculture) [64]. In a similar vein, Washburn et al. have identified seven key infrastructure components and services that constitute smart cities: city management, education, healthcare, public safety, real estate, transportation, and utilities [65]. A. Dang posited that China's new smart city development is propelled by two key factors: application scenarios and digital twins [66].

4.4. The Current Status of Smart City Construction in China

As of now, China is planning and constructing more than 900 smart cities. From a construction layout perspective, all vice-provincial cities, over 89.6% of cities at and above the prefecture level, and over 62.8% of counties have proposed building smart cities and forming a trend of coordinated development of smart city clusters [67], as is shown in

Figure 6. The figure displays two sets of numbers on the left side. The first set represents the number of smart cities planned to be built of each type, while the second set represents the total number of cities in each of those types.

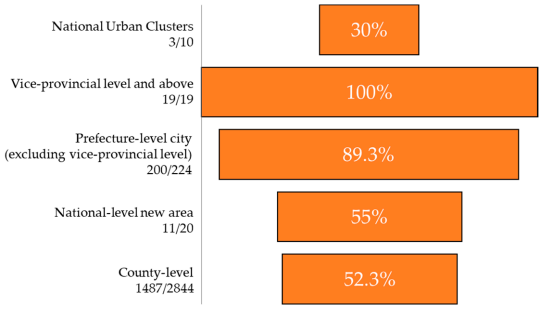

Figure 6. The situation of the top-level design of smart cities at all levels of cities in China.

From the perspective of smart city distribution density, the number of pilot projects is unevenly distributed among provinces and cities, mainly concentrated in the eastern and central regions, with the eastern coastal areas being the most concentrated. From a comprehensive construction situation perspective, first-tier cities such as Beijing, Shanghai, and Shenzhen continue to lead and perform well in smart city strategy, technology, domain, and innovation capabilities. According to the data from China Academy of Information and Communications Technology, the total investment in smart city projects in China in 2021 amounted to RMB 2.79 trillion, and the compound annual growth rate since 2015 is approximately 85%. In 2021, there were 94 smart city-related projects with a scale of RMB 100 million or more, with a total amount of RMB 12.196 billion. In terms of sub-fields, there were 16 smart transportation investment projects with an amount exceeding RMB 4.2 billion, which is the highest proportion [68]. The proportion of smart city construction enterprises in different regions and the proportion of per capita smart city construction enterprises are shown in the Figure 7 below. Figure 7D presents the total number of relevant enterprises and population in each region. To facilitate a more intuitive comparison of the difference in the number of enterprises per capita between regions, we have calculated the ratio of the total number of relevant enterprises and population in each region. We then normalized these ratios and reflected them in a pie chart. This allows for a clearer visualization of the relative proportion of enterprises per capita in each region. In summary, the uneven status of smart city construction between regions and different scale cities continue to exist.

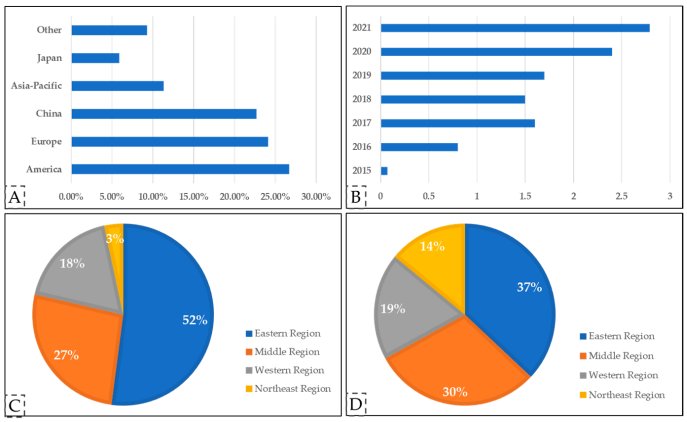

Figure 7. Investment and construction status of smart cities in China. (**A**) Proportion of the smart city market size in major regions worldwide in 2020; (**B**) Scale of central government investment in smart cities in China from 2015 to 2021 (unit: trillion yuan); (**C**) Regional distribution of the number of smart city construction enterprises in China in 2022; (**D**) Regional distribution of the per capita number of smart city construction enterprises in China in 2022.

5. Analysis of the Current Situation and Future Prospects of Smart Cities in China

5.1. Analysis of the Current Situation of China's Smart Cities

The smart city market in China has seen significant growth in recent years, with the China Smart City Working Committee reporting a projected market size of 25 trillion yuan by 2022. This investment scale will make China the second-largest smart city market globally, following the United States. China's push for smart city development has resulted in several rounds of pilot programs and the construction of over 900 smart cities, with coverage extending to all provinces, cities, and autonomous regions across the country. Despite an uneven distribution across regions, the formation of smart city groups has created a synergistic development trend. First-tier cities such as Beijing, Shanghai, and Shenzhen continue to lead the way in comprehensive construction, boasting impressive strategies, technologies, fields, and innovation capabilities.

Although China boasts a large number of smart city construction pilots, the smart city construction development process also reveals several shortcomings. According to our experience, the following major problems widely exist in the process of smart city construction throughout China.

First, too much emphasis has been placed on scale rather than effectiveness. Instead of combining urban construction and development goals and choosing reasonable smart city construction goals, scale, projects, and technical routes, many smart city construction projects pursue large and comprehensive development at the expense of expected results.

Second, the construction of smart cities is often not based on city-specific characteristics. Smart city construction fails to consider a city's unique advantages and main problems in terms of economic construction, the livelihood of residents, and ecological construction. This leads to a simple replication of the experience and methods of advanced cities and model cities, resulting in reduced social, economic, and environmental benefits.

Third, the construction is not deep enough. It does not pursue the quality of data perception, integrity, and data integration and sharing but, rather, aims for the superficial appearance of cameras and big-screen displays. This approach limits the collected data to large screen displays and does not allow experts and enterprises to conduct intelligent analysis, computation, and operation for effective smart city management.

Fourth, too much emphasis has been placed on hardware investment, at the expense of software development and maintenance. Smart city construction involves heavy investments into hardware, including the deployment of cameras, servers, and screens; meanwhile, less than one-third of the project funds are allocated for purchasing software or opening data for data analysis and intelligent computing, building model software, and/or effectively using the collected data for the intelligent operation and management of the city.

Finally, there is too much reliance on government-led initiatives. Most of China's smart city construction is dominated by government input, which has certain advantages in the urban information infrastructure construction stage; however, once the construction of urban information infrastructure is completed, a perfect data opening and management system must be established. In this context, a multi-party construction ecology with government guidance, universal participation, and government–enterprise cooperation should be formed to drive the city's data industry and digital economy. This also allows professional and technical personnel to effectively utilize the data and play key roles in smart city management.

5.2. Thoughts and Suggestions for Smart Cities in China

After considering the aforementioned issues, we propose that the future development and operation of China's smart cities should focus on the following aspects.

First, prioritizing top-level design is crucial, as smart cities are intricate and open systems that require a people-oriented approach. Comprehensive planning based on thorough research and consideration should strengthen the top-level design and fully integrate the concept of "people's city built by people, people's city for people" into the planning and design stage. This should be combined with future development needs and

the situation of high-speed technological iteration, as well as setting reasonable targets, moderately planning ahead, and continuously enhancing the integrity, system, livability, inclusiveness, and growth of the city.

Second, the construction of smart cities should be tailored to the local conditions, including the unique history, geography, cultural background, and development stage of each location. Priorities should be distinguished, and coordination should promote the exploration of development paths and models that reflect the characteristics of the city.

Third, smart city construction should be problem-oriented, focused on solving real problems and addressing needs. It should be based on the demand for traction, focused on the key concerns of the masses, and aimed at solving problems to sustainably achieve urban development and promote the well-being of the people.

Fourth, smart city development should prioritize high-quality development. Data provide an essential lifeline for smart city development, and the effective use of data is critical for the operation of smart cities. Smart city construction should involve breaking down data barriers to effectively leverage data by combining hardware and software.

Fifth, promoting participatory governance is essential to attract the active participation and interaction of different actors, such as the government, researchers, enterprises, and the public, in order to stimulate social vitality. The government and enterprises should cooperate to clarify the boundaries of responsibility, and the public's importance as the demand-side, participant, and evaluator of the construction and operation performance should be considered, thus allowing the needs of the public for a better life to be met.

6. Conclusions

The concept of a smart city encompasses a range of fundamental elements, including subjects, objectives, means, foundations, environments, support systems, and safeguards. These elements interact with one another to form a complex urban system that exhibits shared characteristics across three intersecting layers: physical space, social space, and virtual space. These characteristics are also influenced by the developmental stages of smart cities. The advent of new information technologies has brought about revolutionary changes in information dissemination, which, in turn, has transformed urban operating systems, organizational systems, and institutional systems. Ultimately, these changes affect the relationships between individuals, between individuals and the city, between individuals and nature, and the value propositions of urban development.

This study focuses on the construction of smart cities in China. At the theoretical level, three generations of smart city evolution are proposed and explained. With the rapid development of new information technologies, Smart City 1.0 focuses on realizing the digitization of information, significantly improving the speed, breadth, and accuracy of information dissemination, and laying the foundation for achieving widespread perception, interconnectivity of all things, and comprehensive intelligence. Building on this foundation, Smart City 2.0 breaks down data barriers between departments, achieves the integration and widespread application of massive, multi-source, and heterogeneous data, and promotes the intelligent transformation and upgrading of various fields, providing inexhaustible power for economic development and industrial transformation. The development of intelligent cities promotes the innovation of urban civilization paradigms. Smart City 3.0, building on the achievements of 2.0, returns to the fundamental purpose of improving people's lives in cities, emphasizes public participation in urban governance, and truly achieves the goals of harmony, livability, and smart.

At the practical level, this study draws on the construction status of smart cities worldwide to identify and summarize experiences and lessons that are of great reference significance for the construction of smart cities in China, reducing exploration costs. Furthermore, the study conducts a systematic review of the history, current situation, and policy evolution of smart city construction in China, identifies existing problems, and provides improvement suggestions. The construction of smart cities in China still faces regional differences and should not be simply copied without a thorough understanding

of the theoretical underpinnings of smart cities and taking into account factors such as geographic location, historical and cultural background, resource endowment, industrial characteristics, and population features. Instead, smart city construction plans should be developed based on these practical considerations.

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References

1. Wang, M.; Zhou, T.; Wang, D. Tracking the evolution processes of smart cities in China by assessing performance and efficiency. *Technol. Soc.* **2020**, *63*, 101353. [CrossRef]
2. Shen, L.; Huang, Z.; Wong, S.W.; Liao, S.; Lou, Y. A holistic evaluation of smart city performance in the context of China. *J. Clean. Prod.* **2018**, *200*, 667–679. [CrossRef]
3. Li, C.; Liu, X.; Dai, Z.; Zhao, Z. Smart city: A shareable framework and its applications in China. *Sustainability* **2019**, *11*, 4346. [CrossRef]
4. Li, C.; Dai, Z.; Liu, X.; Sun, W. Evaluation system: Evaluation of smart city shareable framework and its applications in China. *Sustainability* **2020**, *12*, 2957. [CrossRef]
5. Li, X.; Fong, P.S.; Dai, S.; Li, Y. Towards sustainable smart cities: An empirical comparative assessment and development pattern optimization in China. *J. Clean. Prod.* **2019**, *215*, 730–743. [CrossRef]
6. Wu, Y.; Zhang, W.; Shen, J.; Mo, Z.; Peng, Y. Smart city with Chinese characteristics against the background of big data: Idea, action and risk. *J. Clean. Prod.* **2018**, *173*, 60–66. [CrossRef]
7. Bouvier, L.F. Replacement migration: Is it a solution to declining and ageing population? *Popul. Environ.* **2001**, *22*, 377–381. [CrossRef]
8. Lim, T.W. Case study 3: The rise of smart cities in China—Domestic development and comparative perspectives. In *Industrial Revolution 4.0, Tech Giants, Digitized Societies*; Palgrave Macmillan: Singapore, 2019; pp. 117–125.
9. Zhao, F.; Fashola, O.I.; Olarewaju, T.I.; Onwumere, I. Smart city research: A holistic and state-of-the-art literature review. *Cities* **2021**, *119*, 103406. [CrossRef]
10. Bibri, S.E.; Krogstie, J. Smart sustainable cities of the future: An extensive interdisciplinary literature review. *Sustain. Citi. Soc.* **2017**, *31*, 183–212. [CrossRef]
11. Harrison, C.; Eckman, B.; Hamilton, R.; Hartswick, P.; Kalagnanam, J.; Paraszczak, J.; Williams, P. Foundations for smarter cities. *IBM J. Res. Dev. Policy Rev.* **2010**, *54*, 1–16. [CrossRef]
12. Palmisano, S. Smarter Planet. Available online: https://www.ibm.com/ibm/history/ibm100/us/en/icons/smarterplanet/words/ (accessed on 5 December 2022).
13. Ramaprasad, A.; Sánchez-Ortiz, A.; Syn, T. A unified definition of a smart city. In Proceedings of the Electronic Government: 16th IFIP WG 8.5 International Conference, EGOV 2017, St. Petersburg, Russia, 4–7 September 2017; pp. 13–24.
14. Caragliu, A.; Del Bo, C.; Nijkamp, P. Smart Cities in Europe. *J. Urban Technol.* **2011**, *18*, 65–82. [CrossRef]
15. Cohen, B. The 3 Generations of Smart Cities. Available online: https://www.fastcompany.com/3047795/the-3-generations-of-smart-cities (accessed on 10 December 2022).
16. Tahir, Z.; Malek, J.A. Main criteria in the development of smart cities determined using analytical method. *Plan. Malays.* **2016**, *14*, 1–14. [CrossRef]
17. Carrera, B.; Peyrard, S.; Kim, K. Meta-regression framework for energy consumption prediction in a smart city: A case study of Songdo in South Korea. *Sustain. Cities Soc.* **2021**, *72*, 103025. [CrossRef]
18. Patel, M.; Padhya, H. A Smart City Development Concept: The Songdo Experiences. *Int. J. Res. Eng. Sci.* **2021**, *9*, 7–10.
19. Kovalev, Y.; Burnasov, A.; Ilyushkina, M.; Stepanov, A. Political Models of Smart Cities and the Role of Network Actors in Their Implementation (the Case of Vienna, Lyon, and New Songdo in Seoul). In Proceedings of the AIP Conference Proceedings, I International Conference ASE-I-2021: Applied Science and Engineering: ASE-I, Grozny, Russia, 25 June 2021; AIP Publishing: Woodbury, NY, USA, 2021; p. 050002.
20. Thomas, R.M. Inside Smart Cities: Place, Politics and Urban Innovation, by Karvonen, Andrew, Federico Cugurullo, and Federico Caprotti. *J. Plan. Educ. Res.* **2022**, *42*, 497–498. [CrossRef]

21. Correia, D.; Teixeira, L.; Marques, J.L. Reviewing the State-of-the-Art of Smart Cities in Portugal: Evidence Based on Content Analysis of a Portuguese Magazine. *Publications* **2021**, *9*, 49. [CrossRef]
22. Shen, Z.; Guo, Z.; Shen, Q.; Guo, Z.; Sun, L. Promoting China's high-quality development with smart cities. *Inf. China* **2022**, *353*, 92–94.
23. Wang, Y. Rearch on the business development strategy of China Unicom's smart city. Master's Thesis, Shandong University, Jinan, China, 2020. [CrossRef]
24. Li, D.; Shao, Z. Research on Physical City, Digital City and Smart City. *Geospat. Inf.* **2018**, *16*, 1–4.
25. Li, D.; Yuan, Y.; Shao, Z. The Concept, Supporting Technologies and Applications of Smart City. *J. Eng. Stud.* **2012**, *4*, 313–323. [CrossRef]
26. Etezadzadeh, C. The City of the Future. In *Smart City—Future City? Smart City 2.0 as a Livable City and Future Market*; Springer Fachmedien Wiesbaden: Wiesbaden, Germany, 2016; pp. 47–55.
27. Trencher, G. Towards the smart city 2.0: Empirical evidence of using smartness as a tool for tackling social challenges. *Technol. Forecast. Soc. Change* **2019**, *142*, 117–128. [CrossRef]
28. Gascó-Hernandez, M. Building a smart city: Lessons from Barcelona. *Commun. ACM* **2018**, *61*, 50–57. [CrossRef]
29. Capdevila, I.; Zarlenga, M.I. Smart city or smart citizens? The Barcelona case. *J. Strategy Manag. Res. Pract.* **2015**, *8*, 266–282. [CrossRef]
30. Angelidou, M. Smart city policies: A spatial approach. *Cities* **2014**, *41*, S3–S11. [CrossRef]
31. Bakıcı, T.; Almirall, E.; Wareham, J. A smart city initiative: The case of Barcelona. *J. Knowl. Econ.* **2013**, *4*, 135–148. [CrossRef]
32. Brous, P.; Janssen, M.; Herder, P. The dual effects of the Internet of Things (IoT): A systematic review of the benefits and risks of IoT adoption by organizations. *Int. J. Inf. Manag.* **2020**, *51*, 101952.
33. Li, C. Research on the Connotation, Characteristic and Development of Smart City: A Case Study of Smart City Construction in Beijing. *Modern Urban Res.* **2015**, *5*, 79–83.
34. Myeong, S.; Jung, Y.; Lee, E. A study on determinant factors in smart city development: An analytic hierarchy process analysis. *Sustainability* **2018**, *10*, 2606. [CrossRef]
35. Vukovic, N.; Rzhavtsev, A.; Shmyrev, V. Smart city: The case study of Saint-Peterburg 2019. *Int. Rev.* **2019**, 15–20.
36. Pira, M. A novel taxonomy of smart sustainable city indicators. *Humanit. Soc. Sci. Commun.* **2021**, *8*, 197. [CrossRef]
37. Souza, J.T.d.; Francisco, A.C.d.; Piekarski, C.M.; Prado, G.F.d. Data mining and machine learning to promote smart cities: A systematic review from 2000 to 2018. *Sustainability* **2019**, *11*, 1077. [CrossRef]
38. Xu, Q.; Wu, Z.; Chen, Z. The Vision, Architecture and Research Models of Smart City. *J. Ind. Eng. Eng. Manag.* **2012**, *26*, 1–7.
39. *30182:2017*; Smart City Concept Model—Guidance for Establishing a Model for Data Interoperability. ISO/IEC: Geneva, Switzerland, 2017.
40. *Y.4900/L.1600(06/2016)*; Overview of Key Performance Indicators in Smart Sustainable Cities. ITU-T: Geneva, Switzerland, 2016.
41. *GB/T33356-2022*; Evaluation Indicators for New-Type Smart Cities. State Administration for Market Regulation: Beijing, China, 2022.
42. Song, Y.; An, X. Analysis on the Concepts and Conceptual Systems of Smart City in International Standards Based on Terminology Definitions of ISO, ITU-T and IEC. *Stand. Sci.* **2018**, *1*, 127–132.
43. Zhao, D. The Research on the Construction of the Smart City in China. Ph.D. Thesis, Jilin University, Changchun, China, 2013.
44. Xiao, H.; Wang, Z. Systemic Thinking on Smart Cities. *China Soft Sci. Mag.* **2017**, *7*, 66–80.
45. Gang, S.; Qiang, T. Modern Urban Management: An Open Complex Giant System. *Urban Stud.* **2007**, *14*, 66–70.
46. Sheth, A.; Anantharam, P.; Henson, C. Physical-cyber-social computing: An early 21st century approach. *IEEE Intell. Syst.* **2013**, *28*, 78–82. [CrossRef]
47. Wang, F. The emergence of intelligent enterprises: From CPS to CPSS. *IEEE Intell. Syst.* **2010**, *25*, 85–88. [CrossRef]
48. Rodrigues, M.; Monteiro, V.; Fernandes, B.; Silva, F.; Analide, C.; Santos, R. A gamification framework for getting residents closer to public institutions. *J. Ambient. Intell. Humaniz. Comput.* **2020**, *11*, 4569–4581. [CrossRef]
49. Giffinger, R.; Gudrun, H. Smart cities ranking: An effective instrument for the positioning of the cities? *ACE Archit. City Environ.* **2010**, *4*, 7–26. [CrossRef]
50. Marsal-Llacuna, M.-L.; Colomer-Llinàs, J.; Meléndez-Frigola, J. Lessons in urban monitoring taken from sustainable and livable cities to better address the Smart Cities initiative. *Technol. Forecast. Soc. Change* **2015**, *90*, 611–622. [CrossRef]
51. Guo, L.Q. *The Research Report on Standards System of China Smart City*; China Architecture & Building Press: Beijing, China, 2013.
52. Chen, M.; Wang, Q.C.; Zhang, X.H.; Zhang, X.W. Study on the System of Evaluation for Wisdom City Construction-Nanjing as the Case. *Urban Stud.* **2011**, *18*, 84–89.
53. Zhang, Z.Q.Y.; Zou, K.; Xiang, S.; Mao, T.T. Model Construction and Empirical Study on Smart City Construction Ability Assessment. *Sci. Technol. Manag. Res.* **2017**, *37*, 73–76.
54. Giffinger, R.; Kramar, H. Benchmarking, profiling, and ranking of cities: The "European smart cities" approach. In *Performance Metrics for Sustainable Cities*; Routledge: London, UK, 2021; pp. 35–52.
55. Shah, M.N.; Nagargoje, S.; Shah, C. Assessment of Ahmedabad (India) and Shanghai (China) on smart city parameters applying the Boyd Cohen smart city wheel. In Proceedings of the 20th International Symposium on Advancement of Construction Management and Real Estate, Melbourne, VIC, Australia, 20–23 November 2017; Springer: Singapore, 2017; pp. 111–127.

56. Zhejiang Released "Digital Reform Public Data Classification and Grading Guide" Provincial Local Standards. Available online: http://www.gov.cn/xinwen/2021-07/19/content_5625917.htm (accessed on 10 November 2022).
57. Wang, W. The Evaluation Model and Evaluation Standard of New Type Smart City Based on Ternary Space Feedback Control Structure. *J. Int. J. Syst. Sci.* **2023**, *3*, 58–64.
58. IMD Smart City Index 2023. Available online: https://www.imd.org/smart-city-observatory/home/ (accessed on 14 February 2023).
59. Yang, J.; Kwon, Y.; Kim, D. Regional smart city development focus: The South Korean national strategic smart city program. *IEEE Access* **2020**, *9*, 7193–7210. [CrossRef]
60. Angelidou, M. Smart city planning and development shortcomings. *TeMA J. Land Use Mobil. Environ.* **2017**, *10*, 77–94.
61. Lee, J.H.; Hancock, M.G.; Hu, M.-C. Towards an effective framework for building smart cities: Lessons from Seoul and San Francisco. *Technol. Forecast. Soc. Change* **2014**, *89*, 80–99. [CrossRef]
62. Lan, H. The Three Prominent Issues Faced in the Process of Urbanization Advancement. Available online: http://news.ccidnet.com/art/1032/20130810/5117077_1.html (accessed on 18 November 2022).
63. Central Urban Work Conference held in Beijin, Xi Jinping and Li Keqiang Made Important Speeches. Available online: http://www.gov.cn/xinwen/2015-12/22/content_5026592.htm (accessed on 2 February 2023).
64. Liu, P.; Peng, Z. China's smart city pilots: A progress report. *Computer* **2013**, *47*, 72–81. [CrossRef]
65. Washburn, D.; Sindhu, U.; Balaouras, S.; Dines, R.A.; Hayes, N.; Nelson, L.E. Helping CIOs understand "smart city" initiatives. *Growth* **2009**, *17*, 1–17.
66. Wu, Z.; Wang, J.; Li, D.; Ding, L.; Dang, A.; Zhen, F.; Yang, T.; Liu, H.; Yang, J.; Long, Y. Symposium of Calm Thinking amid the Smart City Fervor. *Urban Plan. Forum* **2022**, *2*, 1–11. [CrossRef]
67. Summary Speech of the 2023 China Development Forum. Available online: https://www.drc.gov.cn/Default.aspx (accessed on 19 April 2023).
68. Research Report on the Industrial Map of New Smart Cities in 2021. Available online: http://www.caict.ac.cn/ (accessed on 17 April 2023).