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Future Trends and Current State of Smart City Concepts: A Survey

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ABSTRACT Intelligent systems are wanting for cities to cope with limited spaces and resources across the world. As a result, smart cities emerged mainly as a result of highly innovative ICT industries and markets, and additionally, they have started to use novel solutions taking advantage of the Internet of Things (IoT), big data and cloud computing technologies to establish a profound connection between each component and layer of a city. Several key technologies congregate to build a working smart city considering human requirements. Even though the smart city concept is an advanced solution for today’s cities, recently, more living spaces should be discovered, and the concept of a smart city could be moved to these alternative living spaces, namely floating cities. The concept of a floating city emerged as a novel solution due to rising sea levels and land scarcity in order to provide alternative living spaces for humanity. In this article, our main research question is to raise awareness on the current state of smart city concepts across the world by understanding the key future trends, including floating cities, by motivating researchers and scientists through new IoT technologies and applications. Therefore, we present a survey of smart city initiatives and analyze their key concepts and different data management techniques. We performed a detailed literature survey and review by applying a complex literature matrix including terms, like smart people, smart economy, smart governance, smart mobility, smart environment, and smart living. We also discuss multiple perspectives of smart floating cities in detail. With the proposed approach, recent advances and practical future opportunities for smart cities can be revealed.

INDEX TERMS Smart city, floating cities, IoT, survey.

I. INTRODUCTION

The size and the population of cities are ever-increasing as indicated in worldwide forecast reports [1]. Therefore, everyday life in urban areas will further be challenging due to limited resources and services, such as medicine, education, environment, and transportation. To retain the sustainability of these services in urban areas, novel methods for successful data management should be prioritized. The smart city is a term that is derived from the adoption and application of mobile computing systems through practical data management networks amongst all components and layers of the

city itself [1]. Cities are more focused on their efforts on becoming smarter with the use of data management networks, such as the Internet of Things (IoT), big data and cloud computing technologies. These data management systems provide improvements in different aspects of operations and organizations, such as traffic control, sustainable resource management, quality of life, and infrastructure in the smart city [2].

The IoT system refers to a growing network of digital sensors, smart devices, and smart home appliances. The IoT technology is drawing the attention of citizens, and this rapid attention to these systems will improve the quality of life of people. For example, developing enduring batteries will do much work, and they will be able to power themselves by

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taking advantage of daylight, heat or vibrations in the near future [1]. This is an exact example of the applications that are in development for use in future smart cities. However, each city differs in terms of smart city priorities and primary implementations, and these types of smart devices and systems will be used in the future.

Furthermore, given the increasing population within the urban areas, sufficient services and environmental needs cannot be provided easily; thus, IoT technologies have emerged as a solution for creating a working smart city [3]. Although constructing an IoT architecture is a very complicated task, this data management system has been extensively mentioned for developing smart cities in the latest literature. A large variety of devices, link-layer technologies and services should be incorporated in smart cities as mentioned in [4]. Furthermore, these systems can be easily adapted in different environments such as floating cities, which are one of these environments, and smart cities should evolve as another smart environment on the earth [5].

Rapid development in IoT technologies motivates researchers and scientists in terms of creating new application areas and new IoT services [6], and these new smart services should highly meet the citizens' needs worldwide. Also, to raise awareness on the smart city concepts across the world, human requirements will be taken into consideration by exchanging and collecting data within IoT services. Therefore, the network should be embedded with actuating, networking, computing, and sensing [7]. To monitor, gather, archive and share open sensor data from IoT devices are also important goals to facilitate the development and analysis of smart cities [8]. In the current literature, a large variety of studies exist in terms of different smart city key themes such as environmental monitoring for smart cities [9], quality of life of people in a smart city that mainly focuses on four different city-scale phenomena, including weather, environment, public transport, and people flows [10], data aggregation and quality analysis in a semantic web environment in smart cities [11], [12].

In terms of different perspectives, several researchers have presented various formal definitions of a smart city. In [13], it is defined as the need for a connection between physical, social, business, and information communication technology (ICT) infrastructure to improve the smartness of the urban area. In [14], it is defined as a modern city, which must benefit from ICT to improve the quality of life and quality in urban services for citizens. These two definitions demonstrate that a smart city deals with a smart urban environment equipped with ICT technologies for enhancing everyday city life operations and their performance for individuals [15]. As a result of the evolution of ICT technologies, there is a need for different smart city concepts and themes (i.e., smart people, smart transportation, etc.), which should mainly take the advantages of data management technologies (i.e., IoT, Big Data and Cloud Computing, etc.) to establish a profound connection between each component and layer of a city.

The existing literature provides research on various components such as smart people, smart economy, smart governance, smart mobility, smart environment, and smart living. However, many of these terms are defined in several articles, and these components change according to preferences. For instance, one smart city might take into consideration a disaster management system that belongs to the category of smart community theme, or another city might focus on the integration of the waste management system into the city [15]. Most of these themes are discussed in detail in Section 3.

On the other hand, although the smart city is an innovative solution for urban areas, recently, more living spaces can be explored, and the concept of a smart city may be moved to these alternative living spaces. City planners, engineers, and researchers have been searching for these alternative living spaces for years. Thus, due to the rising sea levels, natural disasters, and harmful human activities, floating settlements or cities have emerged as a new solution for individuals who are searching for optional habitats for human beings. There are several advantages and benefits of these optional habitats, i.e., floating cities, such as providing an eco-friendly environment, easy and fast construction on the sea level, easily removed and expanded construction modules, durability against seismic shocks and cost-effective solutions. Moreover, smart city solutions and themes could be considered within the concept of floating settlements or cities. Therefore, based on the results of our survey, we propose a new approach, namely, "Smart Floating Cities (SFC)", which is an integration of smart city themes with the design of floating settlements. As smart city concepts have emerged as novel solutions to the limited environmental resources and human requirements across the world, these concepts can be integrated into the concept of floating cities, which becomes necessary due to the rising sea levels. Also, since the rising sea levels are highly damaging natural disasters across the world as a result of global warming, the concept of "Smart Floating Cities (SFC)" can be considered as a highly important precaution to the rising sea levels and limited environmental resources.

The method of this review study is based on the analysis of the existing literature in detail by extracting the main keywords from the Web of Science, which has been generally preferred to be studied in the previous works. Also, we put forward a survey for smart city concepts by analyzing their key themes in our research, thus we perform a detailed literature search and review by applying a complex literature matrix including terms, like smart people, smart economy, smart governance, smart mobility, smart environment, and smart living.

The rest of the paper is organized as follows. Section II provides a theoretical background of this review by analyzing different smart city themes and the architecture of smart cities. These identified themes, including smart people, smart economy, smart governance, smart mobility, smart environment, and smart living, are defined and analyzed based on

previous studies. We present the methodology of this review in Section II, whereas the results of the conducted research methodologies are given in Section IV. The key aspects are highlighted and limitations are reported in Section V. Finally, the concluding remarks and future trends are given in Section VI.

II. THEORETICAL BACKGROUND

In [16], the smart city is defined as “a smart city is the one that manages such developments by excelling in multiple key sectors such as economy, mobility, environment, people, living, and government”. Following this definition, we performed a deep literature survey to reveal important definitions of smart city concepts and themes.

Lazaroiu and Roscia [17] defined one of the most important characteristics of their smart city as sustainability since the cities are responsible for consuming 75% of worldwide energy production and generating 80% of CO₂ emissions. They developed a model aiming to promote energy efficiency issues and balanced use of energy resources. Yamagata and Seya [18] discussed suitable land use within the city through PV integrated and energy-efficient building design and smart grid systems. They suggested that a compact urban city form reduces the residential electrical demand of the city. Calvillo *et al.* [19] defined their smart city as a sustainable and energy-efficient urban center in a Green and Sustainable Science and Technology category. They stated that a sustainable city should optimize resource management and provide a high quality of life. In this context, they used simulation modeling to assess technological and policy effects of smart solutions.

Galan-Garcia *et al.* [20] proposed a city model that has a good traffic flow with smart traffic lights and signals in a cost-effective manner; they obtained a mixed model that has a combination of cellular automata and neural network theories.

Smart city applications within the context of economic growth, social relations and leadership issues [21]–[23]. Yeh [23] focused on developing a model related to municipal and governmental cooperation. It was concluded that smart cities should invest resources by providing prosperity and contentment and enable corporations. In addition to the above, it was concluded that smart citizens should bring their intelligence and innovative concepts to the city.

A. ANALYSIS OF SMART CITY CONCEPTS BY THEMES

Several key components that constitute a smart city are reported in the literature; thus, some of these components, such as smart people, smart economy, smart governance, smart mobility, smart environment, and smart living, are of interest in this survey.

However, the key themes could change based on the requirements and the priorities of the city itself. As long as the technological developments satisfy human requirements, more future research should be encouraged to both analyze

and optimize different standards and perspectives in terms of smart cities.

In this study, we present the main smart city themes derived from the literature by extracting the smart city definitions from Q1 and Q2 journal articles in the Web of Science. We define them one by one in the following subsections as smart people, smart economy, smart governance, smart mobility, smart environment, and smart living.

1) SMART PEOPLE (CITIZENS)

Improving the living environment and increasing the quality of life are two significant goals of smart cities [23] since people are the main users of smart devices and services. Therefore, it is quite important to both plan and design these services properly [23]–[27].

Critical aspects of living in smart cities are discussed in the literature. Chatterjee and Kar [25] studied the factors that affect the usage of information systems within smart cities based on the quality of information and systems. Belanche-Gracia *et al.* [24] discussed privacy and security concerns related to the investigation of the smartcard services for public facilities and transportation. According to Yeh [23], social networking systems should be highly considered since they educate people about smart city systems and services by providing useful information. All of these factors should be carefully adopted and given attention since they improve the quality of life of people [12].

People in smart cities should connect and communicate with each other to exchange common and imperative online social experiences and share physical space with users [28], and [29]. Smart people should not only interact with each other via services, but they should also provide data for these services. For example, the study by Niforatos *et al.* [30] proposed a crowdsourcing weather application that combines automatic sensor readings from smartphones and manual input by people to assess data on existing and future weather events. Mone [31] performed a cycling route crowdsourcing-based study to strengthen the citizen value element and underline possible long-term profits for cyclists. These data were used by city planners to both analyze traffic and expand city structure by adding racks or widening lanes.

Smart people should also be open-minded, easily adapt themselves to changing environmental conditions, and be creative as they are the heart of the smart cities. People as citizens should participate in each transformation in the city itself because they are building the whole city, and they should ask themselves what type of city they want. People should be educated about laws and policies to use the environment of information processing. Additionally, social networking services should educate people about smart city systems and services, which provide information [12].

2) SMART ECONOMY

A smart economy also relates to smart business and mobile commerce within the term of the smart city [32], [33]. Johnson *et al.* [32] presented a predictive and probabilistic

architecture modeling background, which relates to a risk-based approach and management of shifting market situations within a business. Many of the potential and commercial benefits relating to the smart economy and the interaction between the economy and citizens have been reviewed in studies in the existing literature [12]. Keegan *et al.* [34] reported that e-commerce services can operate in a digital city by supporting retailers to gain the attention of more customers. This study describes a mobile shopping system for a potential shopper that provides information about any product that the customer is interested in buying. However, balancing the relationship between innovation and user experience in the context of a smart economy that takes into account privacy concerns of citizens remains a challenge [12].

3) SMART GOVERNANCE

Governments could successfully use social media by encouraging people or citizens to participate and collaborate in smart cities [12]. In [35], it is indicated that using social media is an effective strategy; however, the government should be involved in the process. Also, clear communication should be provided, and issues related to security and privacy should be enhanced. In [36] it was shown that a civil partnership could support the design, implementation and evaluation processes of smart city projects using Barcelona city as an example. Rana *et al.* [37] concluded that the government is the most important barrier for promoting e-governance services to make the decision process of smart cities transparent.

The successful government in smart cities depends on providing city services, channels, smart mobile services, and network integration to the citizens [38]–[42]. Furthermore, smart governments should not only be progressive in chasing technological developments but also they should have smart governmental management and policies, which enable citizens to be integrated into the processes [12].

In [43], metrics were proposed to evaluate the smartness of government initiatives: efficiency, effectiveness, transparency, and collaboration. In [44], the different dimensions of government, such as integration, innovation, evidence-based decision-making, citizen centricity, sustainability, creativity, effectiveness, efficiency, equality, entrepreneurialism, citizen engagement, openness, resiliency, and technology savviness, were discussed within the context of smart cities.

The necessities for sustainable governance of amenities within smart cities should be supported by Cloud-based Information Systems (IS) services [45]. To improve citizen participation and engagement, IS and associated services should be promoted via integration between stakeholders and government agencies; thus, creating collaborations in any environment would increase the efficiency of smart governance concepts [46].

4) SMART MOBILITY (SMART TRANSPORTATION)

Managing the intensities of vehicle capacity based on urban congestion is one of the major difficulties that cities are

currently facing, and this issue is discussed in scientific articles regarding intelligent transportation systems [47], [48]. Internet of Vehicles (IoV) has emerged as a solution through playing a serious role in intelligent transportation systems. In this context, there are a variety of applications to develop efficiency in traffic safety [49]. For instance, Zhu *et al.* [50] used a Hybrid Emergency Message Transmission (HEMT) system through IoV to provide compatible and scalable network management.

In [47], it was highlighted traffic management by discussing urban traffic management, and they finally proposed a solution for drivers that allows them to successfully reach their destination without experiencing road congestion. Calderoni *et al.* [51] proposed a system that could gather information from different sensor networks by identifying two services. The first system involved mobile traffic control, and the second system was Wise Traffic Controller (WTC). These two services improved the traffic flow and urban road infrastructure based on traffic management policies.

In [52], they focused on vehicle tracking by proposing a novel technique that enables real-time tracking of moving vehicles. Through several simulations, this technique improved tracking of multiple vehicles simultaneously and predictions of a possible centroid area of a tracker. Zhang *et al.* [53] assessed route stability by proposing a new routing algorithm, termed Power Controlled and Stability-based Routing protocol (PCSR), to improve energy efficiency and route stability. In [54], they focused on a smart metro by using secondary data to investigate the competitiveness of four metro cities in India, including Delhi, Kolkata, Mumbai, and Chennai. The authors explored smart city initiatives and assessed the possibility of implementing these initiatives in these metro cities to develop smart cities.

5) SMART ENVIRONMENT (SUSTAINABLE RESOURCE MANAGEMENT)

Recently, smart environments have gained popularity with the help of researchers, and these environments are one of the most significant characteristics of smart cities [12]. Air quality, green and water spaces, emission monitoring, waste management, energy efficiency and monitoring of city trees are studied in [30], [53], [55]–[59] respectively to constitute a smart environment. Furthermore, Al-Hader *et al.* in [61], the authors tried to solve the problem of monitoring city trees within the context of smart cities. Since the trees in urban areas could damage the cables and cause the power disconnections, a dynamic laser scanning system was developed to locate well-organized trees in the city.

Castelli *et al.* [58] stated that air pollution can cause environmental damage, and cities are currently facing this problem. According to the WHO, people are dying every year due to air pollution. Therefore, some studies focused on air quality monitoring and prediction through traffic monitoring sensors [58], [59]. In [60], it is presented a prototype that works with an IoT-based decision support system that monitors air pollution using effective pollution reduction methods.

The proposed model also works with basic traffic models used for atmospheric models to predict traffic-related air pollution.

The proper organization of water management within swarming cities is a challenging issue [61]. Furthermore, huge crowds and the increasing population in cities pose certain challenges, such as aging water infrastructure, prohibitive maintenance costs, new contaminants, etc. [61], [62]. Because of these issues, proper water management systems should be developed. Some researchers found that ICT systems could improve drinking water quality across the world [57], [63]. For instance, Corbett and Mellouli [57] proposed a conceptual model that contributes to the IS in sustainable smart city design. According to the model, three different interrelated issues, namely, administration, policy, and sustainability, were explained.

Waste management is another significant issue in sustainable smart cities. This issue directly affects the quality of life of people who live in urban areas [12]. Numerous studies address IoT-based waste management systems [56], [64], [65]. In one study [56], dynamic waste collection architecture was proposed based on data provided by the sensors. This study focused on high waste collection areas, such as schools, hospitals, and universities, due to the presence of highly damaged waste collection, which could damage the quality of life of citizens.

6) SMART LIVING (SMART BUILDING, QUALITY OF LIFE)

Smart buildings for education, tourism, healthcare, and public safety comprise the term smart living, and these aspects could improve the quality of life of citizens. One of the major concerns in smart living is public safety as it affects the growing urbanization in developing countries [12]. Public safety has been investigated using ICT tools in several studies [66], [67]. For example in [66], a crowd-sourcing model was proposed and tested through citizen participation in South Africa. The usability of an Interactive Voice Response (IVR) was tested, and this system could be an effective tool for citizens to report safety problems. Another study [67] showed that IVR is a very useful system since it is easy to learn and efficient.

According to some studies [68], [69], [70], healthcare issues are also noteworthy to study to assess the quality of life of the citizens in the smart cities. Hussain *et al.* [68] developed a framework for people-centric health management using real-time monitoring for elderly and disabled citizens of smart cities. People's health was studied through emergency support for their special care and needs within a virtual community. Pramanik *et al.* [69] presented their framework for a big data-enabled Smart Healthcare System by providing demonstrations of a healthcare-connected business model. This framework minimized health costs, improved contact management and achieved better service quality.

Vincent [71] stated that the quality of education services has a high impact on the quality of smart cities within local development. Ortiz-Fournier *et al.* [72] presented an integrated model on educational infrastructure to develop a

comprehensive strategic plan and solve many of the region's problems.

Gretzel *et al.* [73] proposed a Smart Tourism Ecosystem (STE) that takes advantage of smart technology in the context of creating, managing and delivering smart tourism services. This ecosystem was characterized by serious information allocation and value cocreation by tourism stakeholders. The proposed STE also provided great opportunities and technological advances to innovative business models and value to the co-creation environment.

The concept of smart buildings has become very popular, especially for citizens who use their mobile phones while communicating [12]. For instance, the NomaBlue prototype, which facilitates smart nomadic data collection with the help of Bluetooth technologies, was introduced in the study by Boukhechba *et al.* [74]. Together with its associated navigation potential, NomaBlue could be used for marketing in terms of personalized shopping. One of the major opportunities of this technology is that it does not require a continuous Internet connection and predefined geographical databases.

B. ANALYSIS OF THE ARCHITECTURE OF SMART CITIES

In order to design a smart city architecture, it is important to take into consideration the context of the city. Thus, we should have a definite vision about environmental situations that citizens are constantly exposed to. With this in mind, the three-dimensional architecture concept is highlighted in this survey on the IoT, big data, and cloud computing, which are also the main pillars of smart solutions. These pillars are quite comprehensive since they will help the cities and the citizens to deal with large-scale streams of data and services.

1) INTERNET OF THINGS (IoT)

The term "Internet of Things (IoT)" was first introduced in 1999 after the introduction of Internet-based techniques in the '90s [76], [77]. As defined in the technical report of Sundmaeker *et al.* [78], IoT is a global infrastructure that provides advanced services by connecting physical and virtual things by ICT. IoT covers Internet-based technologies together with user needs or user applications, which means with IoT devices, even larger concepts of automation systems could be controlled based on the priorities of the users [79], [80]. With the aid of IoT, devices can "talk" simultaneously using different techniques, such as smart computing, embedded devices, and sensor networks. In fact, IoT is a method of making many of the traditional communication devices "smart". Regarding the development of cloud technology, sensor use with IoT has been efficiently expanded in many areas in recent decades. Moreover, by the end of 2020, 50-100 billion devices will be connected to the Internet using various ICTs [78]. Figure 1 illustrates the use of smart home applications and the projected increase in smart devices connected to the Internet by 2020.

Based on the study by [81], IoT is categorized into two domains, including application and technology domains.

SMART HOMES

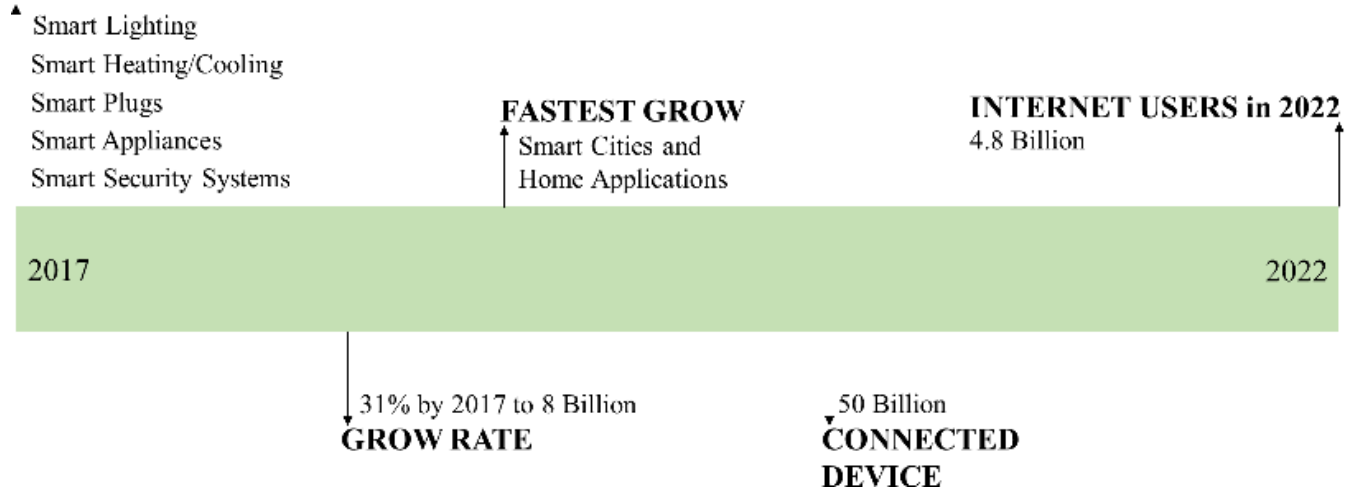


FIGURE 1. The projected growth of smart devices connected to the Internet by 2020 [75].

In the technology domain, users deal with real-time history data with the help of different sensory mechanisms [82], and the technology domain characterizes IoT network architecture based on the referring network, namely, Quality of Service (QoS) [83]. Moreover, with the use of IPv6-enabled architecture [84], flexible IoT categorized architecture models and smart grid IoT systems for energy management [85]–[87], researchers have been integrating them to the automation systems mostly. On the other hand, the application domain has also been rapidly growing and studied in different scientific works [88]–[90]. For instance, researchers have been using IoT in different modern city applications, such as cyberville, digital city, information city, smart city, and wired city [91]. Furthermore, different applications of IoT have been developed to dates, such as IP cameras [92], smart wheelchairs [93], building information management, early warning systems based on cloud services [94], and Web of Things (WoT) [95], [96].

Through rapid improvement in IoT technologies and applications, various approaches have been proposed within smart city implementations. Recently, researchers have been focusing on the potential of IoT in sustainable smart city development. Smart cities and smart buildings are two major application domains that take advantage of IoT technologies.

2) BIG DATA

To store and further process data, the cloud should be used as a platform for offloading these data, which are also produced by IoT devices. In addition, IoT data could be rendered as big data that supports Cloud Computing environment usage to overcome the difficulty of IoT-generated big data [97].

Cloud-driven IoT-based big data have some advantages, and its role provides some opportunities [98]–[100]. For instance, data in an IoT environment, which are also produced by smart IoT devices, could experience exponential growth in time. With the help of big data technology, exabytes of data

could be collected to be processed efficiently and logically for making correct decisions. Conventional methods are not cost-effective when dealing with significant amounts of data, and these methods are not suitable for data processing and storage systems; thus, big data generated by IoT devices could support these cases.

Expectations from smart cities are increasing due to large amounts of growing data. Therefore, such enormous amounts of data or, namely, big data, which are rendered by IoT, are the main kernels of city facilities [101]. The term “big data” is characterized by volume, velocity, and different data types [102], [103]. With the help of big data technology, a city could obtain treasured perceptions from substantial data collected through different sources [101].

Currently, various data sources, such as smartphones, computers, global positioning systems, sensors, and cameras, generate a large amount of data. Therefore, effective data storage and processing pose difficulties to conventional data mining methods [101]. However, big data can be used to generate valuable information from the large amount of data that is generated by sensors and devices. Also, the effective use of big data could be a key factor for successful businesses and service domains. Furthermore, the application of big data in smart cities has many advantages and limitations due to the availability of large computational storage facilities for processing these data within smart cities. However, one of the most significant advantages of this big data technology is its reliance on Cloud Computing and IoT services [101].

Most of the implementations of big data in smart cities necessitate intelligent networks, which have compound connections between components and residents’ equipment, such as smartphones and cars. Thus, this smart network should have the potential for effective transfer of collected data from the resources and transfer of responses back to the entities. Thus, quality of service (QoS) is quite significant for real-time big data applications within smart cities [101].

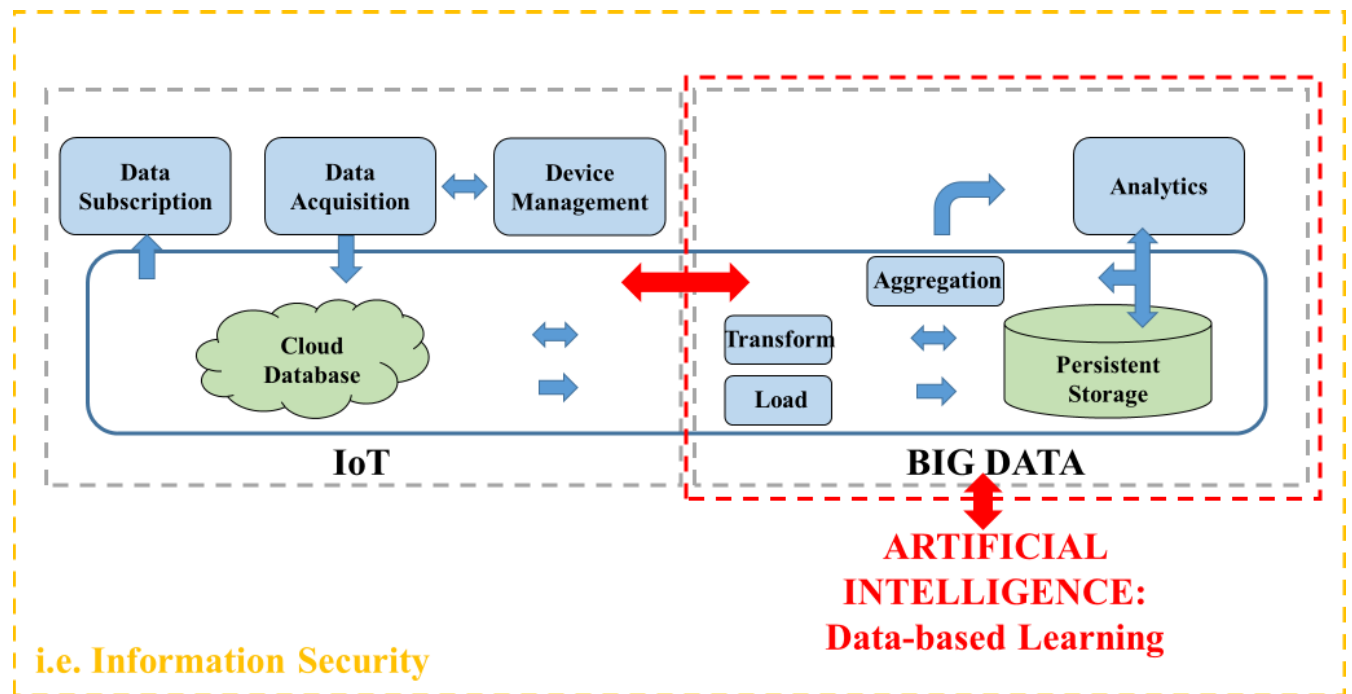


FIGURE 2. The relationship among IoT, Big Data and Cloud Computing.

3) CLOUD COMPUTING

To process big data, Cloud Computing represents a good solution. Cloud computing is an archetype that provides access to a common platform of computational resources that can also be used by cloud users. Cloud Computing, for instance, can propound various benefits to both organizations and individuals within capital savings and expenditures [104]. Figure 2 describes the relationship among IoT, Big Data and Cloud Computing according to the references [79], [97] and [104]. We merged these ideas and propose this scheme, but in our current work we refrain from discussing security issues and AI methods.

The users of Cloud Computing obtain the benefit of a network-based environment, which provides an opportunity of sharing resources and calculations from a certain location [104]. According to the National Institute of Standards and Technology's (NIST) [105] Cloud Computing Definition, Cloud Computing is a type of template that supports proper Internet access, a collective pool of programmable grids, storage systems, software, and servers that could be quickly set free via communication from a provider.

The users of Cloud Computing do not exactly know the precise location of their sensitive data since different security difficulties and dangers exist in data centers in physically circulated places. Additionally, popular security methods, such as firewalls or host-based antivirus software, cannot provide suitable security platforms in virtualized systems given the fast propagation of threats [104].

Furthermore, Cloud Computing provides immediate access for hardware resources to organizations together with

restricted upfront investment and cost-effective maintenance [106]. Cloud Computing is also known as an effective enabler that improves operational activities and agility [107].

Two different perspectives exist in Cloud Computing, namely, technical and client perspectives [107]. For instance, regarding the technical perspective, security, virtualization, architecture, and pricing models are important [108]. However, regarding the client perspective, the focus point is related to barriers and opportunities for clients [107]. For example, in the study by Chen and Wu [109], switching costs, security and privacy issues have been identified within the cloud infrastructure. Battleson *et al.* [107] also discussed the dynamic capabilities that can be accelerated by Cloud Computing.

Some studies make use of the compound connection of Cloud Computing and IoT. For example, a new platform is presented in [110] for Cloud Computing potential and support for smart connectivity and real-time applications for smart cities. Furthermore, a framework for data obtained from highly scattered, assorted, reorganized, real and virtual devices was also presented. This framework could be automatically managed, analyzed and controlled by cloud services.

III. METHODOLOGY

A. SEARCH STRATEGY

We used the VOS viewer software [111]–[113] to extract the key themes in smart cities as seen in Figure 3. To create this figure, we performed a detailed literature search in the Web of Science using keywords such as “smart city” and “concept”.

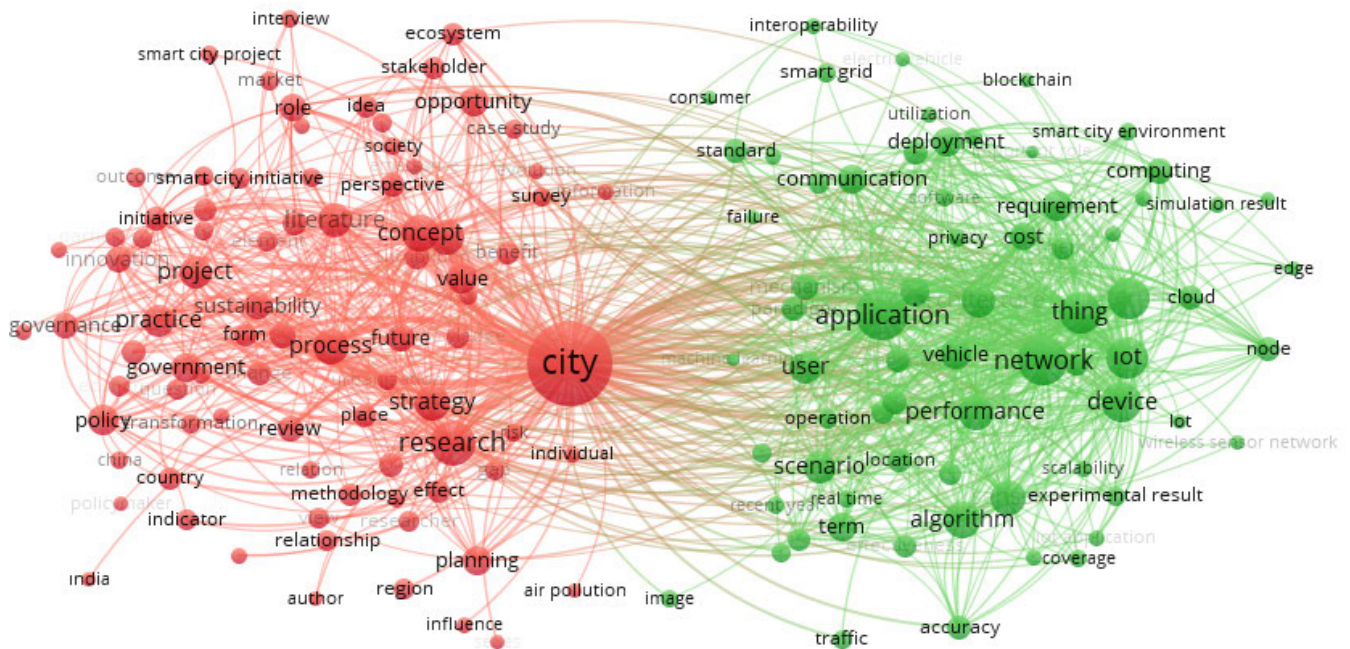


FIGURE 3. The network visualization of smart city themes.

In total, 155 items (i.e. keywords), 2 clusters, and 8034 links were extracted from the network visualization that belongs to 500 articles (224 articles, 228 book chapters, 58 review articles) in the Web of Science. In Cluster 1, citizens, economy, governance, policy, and sustainability are summarized whereas transportation, healthcare, privacy, and security are important keywords were gathered to Cluster 2. The most used keywords with parameters are presented in Table 2, which explains which item belongs to which cluster number, and how many links and occurrences the items have. For instance, Cluster 1 is presented in red, whereas Cluster 2 is presented in green. Therefore, the item “citizen” is located in Cluster 1 and has 149 connections with other keywords and an occurrence rate of 62.

B. ARTICLE SELECTION AND DATA COLLECTION

Different definitions of the term of smart city have been proposed in several journal articles belonging to various journal categories in the Web of Science since 2012. We performed a detailed literature survey of the corresponding studies and gathered the ones published in high-impact factor journals having Q1 and Q2 rankings in Table 1. The definitions found mostly relate to the priorities and the characteristics of a smart city.

We designed a detailed literature matrix for applications of smart cities based on evaluations of smart city themes, proposed methods, benefits, and limitations. A total number of 18 articles published between 2012 and 2019 are categorized in Table 2 to provide a brief, but also a comprehensive matrix. Particularly in the last years, the number of studies on smart cities has increased, revealing technological progression. Figure 4 shows the number of definitions based

on years. As shown in Figure 4, an increase in definitions is observed from 2012 to 2019. Additionally, based on the definitions in Table 1, the concept of a smart city is going in the direction of integration of Information Technologies rather than energy-related sustainability issues. However, regarding the findings in Figure 5, the most cited journal articles are published in energy and sustainability-related journals. The Renewable and Sustainable Energy Reviews journal has the highest number of citations followed by Applied Energy. The Energy Journal is in third place with 14475 citations in total.

Furthermore, the main key point of each article with distinctive methodologies is given in the literature table. Table 3 was inspired by the literature table that was correlatively created in the review article in [114]. Consequently, according to Table 3, information graphics from the previous studies on smart cities are provided, and a meticulous discussion stating the relevant articles is provided in the subsequent section.

IV. RESULTS

Given the significance of smart cities in the scientific area and real-world applications, we gathered the relevant studies between 2012 and 2019 in the existing literature and presented in Table 3. The publication timeline of these studies is shown in Figure 6. Considering this scatter plot diagram, it is quite clear that the relevant studies on smart city applications are increasing, especially in 2019, because the topic currently is very popular.

Figure 7 shows significant criteria for the categorization of the relevant works in this research. Most studies are related to computer science methodology, which is basically composed of fuzzy logic, simulation, cellular automata,

TABLE 1. Current smart city definitions from the Web of Science.

Definition	Year	Journal	Category (Web of Science (WoS))	Journal Rank (WoS)	Citation (May 2019)
"Smart city is a city that represents a community of average technology size, interconnected and sustainable, comfortable, attractive and secure" [17].	2012	Energy	Thermodynamics	Q1	14775
"Smart city is a city that combines appropriate land use (compact city with energy-efficient buildings and PVs), transportation (EV and public transportation system) and energy systems (smart grid)" [18].	2013	Applied Energy	Engineering, Chemical	Q1	22175
"Smart city is a city that has good control of the traffic flow within the city" [20].	2014	Journal of Computational and Applied Mathematics	Mathematics, Applied	Q1	1461
"Smart city is a city that has smart energy meters, security devices, smart appliances for health and domestic life: these and more offer unprecedented conveniences and improved quality of life" [115].	2014	Journal of Advanced Research	Multidisciplinary Sciences	Q1	900
"Smart city is a city that has the provision of intelligent applications that control the entire line of waste management based on sensor observations facilitates the necessary processes and maximizes the performance" [56].	2015	Journal of Systems and Software	Computer Science, Software Engineering	Q1	934
"Smart city is a city that can integrate and synchronize formal leadership and endogenous democratic participation in the IT-based urban ecosystem" [21].	2015	Journal of Business Research	Business	Q2	2760
"Smart city is a city that is intended to deal with or mitigate, through the highest efficiency and resource optimization, the problems generated by rapid urbanization and population growth, such as energy supply, waste management, and mobility" [19].	2016	Renewable and Sustainable Energy Reviews	Green and Sustainable Science and Technology	Q1	22565
"Smart city is a city that has as a network which should be capable of efficiently transferring the collected data from their sources to where big data is collected, stored, and processed and to transfer responses back to the different entities" [101].	2016	International Journal of Information Management	Information Science and Library Science	Q1	849
"Smart city is a city that implements sparking economic growth and social development, facilitated by collaborative dialogue and innovations in technology" [22].	2017	Business Horizons	Business	Q2	352
"Smart city is a city that contributes to social stability and economic prosperity by encouraging and enabling corporations to invest their resources and expertise in the cities, and by providing more prosperity and contentment for their citizens" [23].	2017	Government Information Quarterly	Information Science and Library Science	Q1	465
"Smart city is a city that promotes the automatic and efficient management of urban infrastructures and services, reduction in public spending and improved service quality, focusing on aspects such as energy-saving, sustainable mobility, e-government, social care or security" [116].	2018	Telecommunications Policy	Telecommunications	Q2	288
"Smart city is a city that requires a proper governance system for connecting all forces at work, allowing knowledge transfers, facilitating decision-making in order to maximize their socio-economic and environmental performance" [117].	2018	Cities	Urban Studies	Q1	757
"Smart city is a city that combines advances in the Internet of Things, Big Data, Social Networks, and Cloud Computing technologies with the demand for cyber-physical applications in areas of public interest, such as Health, Public Safety, and Mobility" [118].	2019	Future Generation Computer Systems	Computer Science, Theory and Methods	Q1	6411
"Smart city is a city that uses information communication technologies to enhance the quality of life for residents, the use of modern technologies to increase efficiencies in order to better utilize available resources, the strive for increasing sustainability in order to meet commitments set by international organizations and the fostering of a culture of creativity and innovation that attracts educated workers to further create knowledge-based solutions to a city's challenges" [119].	2019	Pervasive and Mobile Computing	Computer Science, Information Systems	Q1	568
"Smart city is a city that achieves its targets, such as security, mobility, scalability, latency and deployment" [120].	2019	Journal of Network and Computer Applications	Computer Science, Hardware and Architecture	Q1	1732

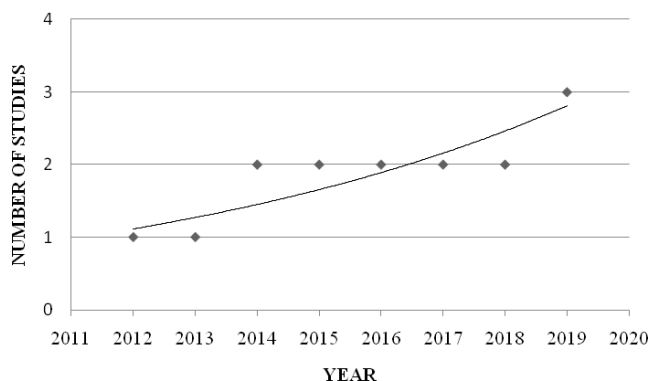


FIGURE 4. The number of smart city definitions in Q1 and Q2 journal articles between 2012 and 2019.

TABLE 2. The most used keywords in Vos viewer.

Item (Keyword)	Cluster no.	Links	Occurrences
Citizen	1	149	62
Economy	1	102	24
Governance	1	110	34
Policy	1	120	46
Sustainability	1	120	37
Transportation	2	120	31
Healthcare	2	71	15
Privacy	2	87	17
Security	2	129	41

and neural network. However, the most studied method is analysis and modeling as in [21], [19], [116], [121], [124] and [125]. For example, Calvillo *et al.* [19] studied the energy management and planning strategies in smart cities by reviewing energy-related works. The second most studied method is data collection and survey analysis, representing 25% of the studies.

Figure 8 highlights that the considered studies involve different smart city themes, including smart governance, smart mobility, smart energy, smart environment, smart urbanization, smart security, smart waste management, smart technology, smart business, smart citizens, smart living, and smart economy. The most studied smart city theme within these papers is smart governance [17], [21], [116], [122], and the second most studied smart city themes include smart transportation [17],[18], [123], smart energy [17],[18], [125] and smart environment [17],[18], [120], which are generally based on sustainability issues. To name the most detailed example among these studies, Lazaroiu and Roscia [17] researched smart city indices by developing a sustainable city model. Moreover, the computation of the indices mentioned in this study included a smart economy, smart environment, smart energy, smart mobility, and smart governance. In this study, the proposed framework used a fuzzy logic method to estimate “the smart city”.

To summarize these results, we can state that an ideal smart city should reflect the most popular themes, and implement services related to these categories. The most likely approach we found in the literature having these properties is the approach of smart floating cities [127]. The goal of any floating city or settlement is to explore optional living spaces and prevent human suffering across the world. Without question, some smart city principles should be employed to make a floating city smart and sustainable. In the next section, we reveal and discuss the future trends of smart city design, and argue that smart floating cities are the most likely to fulfill the needs and requirements represented by the identified themes in this survey.

V. DISCUSSION

As an extension to the smart and sustainable city aspects revealed before, some applications and developments have been made for the floating city concept. For example,

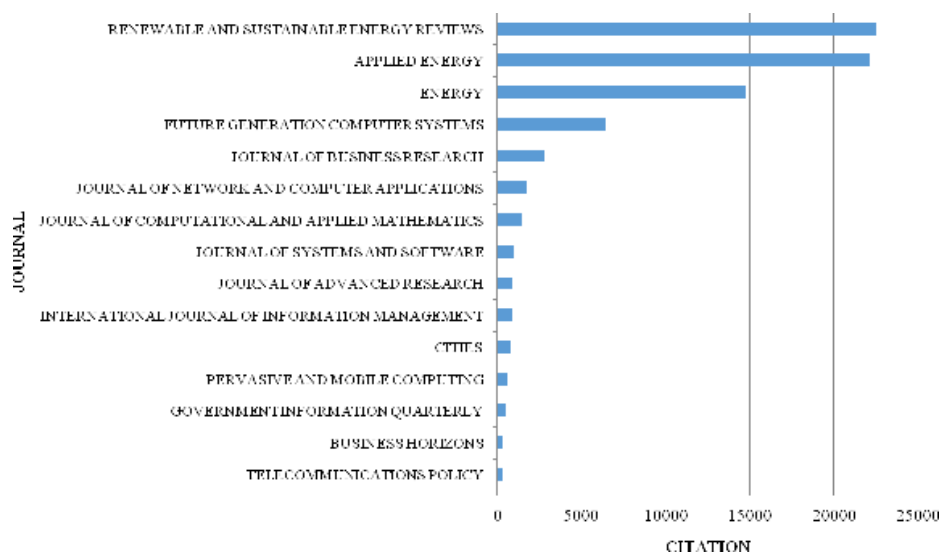


FIGURE 5. Citation numbers for mentioned Q1 and Q2 journals through May 2019.

TABLE 3. Previous applications and scientific studies on smart cities.

Reference	Year	Themes	Proposed method	Benefits	Limitations
Lazaroiu and Roscia [17]	2012	Smart economy, smart environment, smart energy, smart mobility, smart governance	Fuzzy logic	More extensive comprehension and simple use both for decision-makers and citizens	Nonhomogeneous and large amounts of information
Yamagata and Seya [18]	2013	Smart land-use, smart energy, smart transportation	Simulation and scenario analysis	Compact urban form reduces the electricity demand from the residential sector compared with the dispersion sector	Data demanding and computationally difficult
Galan-Garcia et al. [20]	2014	Smart traffic lights, smart signals	Cellular automata and neural network	Flexible and easy tool to simulate traffic flow in a city using smart signals.	Sophisticated computer implementations
Elmaghraby and Losavio [115]	2014	Smart security, smart privacy	GPS tracking device	Available at a relatively low cost and a substantial quantum of intimate information	It can lead to false leads and injudicious actions by some wrongly accused individuals and groups
Anagnostopoulos et al. [56]	2015	Smart waste management	Simulation and dynamic waste collection architecture	Dynamically responds to changes in the production of waste in high priority areas	Unexpected scenarios regarding waste production concerns
Letaifa [21]	2015	Leadership, democratic participation	Longitudinal analysis and data collection	A methodological framework for the implementation of smart cities.	N/A
Calvillo et al. [19]	2016	Smart energy, smart grid	Energy system modeling	One of the best systems at minimum cost, fostering smarter and more-efficient cities.	Selection of system parameters and energy constraints
Yeh [23]	2017	Smart citizens, smart living	Self-administered questionnaire	Embarks on smart city initiatives	Nonofficial demographic distribution of data collection
Navarro and Marco [116]	2018	Smart governance	PEST (Political, Economic, Social and Technological) analysis	Presents new trends in governance in cities and more concrete complex networks and network performance.	N/A
Esposte et al. [118]	2019	Inter smart city	Smart city simulator	Capable of scaling up and down horizontally to handle a varying workload.	Does not integrate other smart city scenarios and enable cross-domain experiments.
Curzon et al. [119]	2019	Smart privacy	A detailed review of existing privacy enhancing technologies	N/A	N/A

the AT Design office in China designed a four-square-mile floating island. Regarding the statements of the architect

Slavomir Siska, this floating city project builds up a new urban nucleus of world-class residential, commercial and

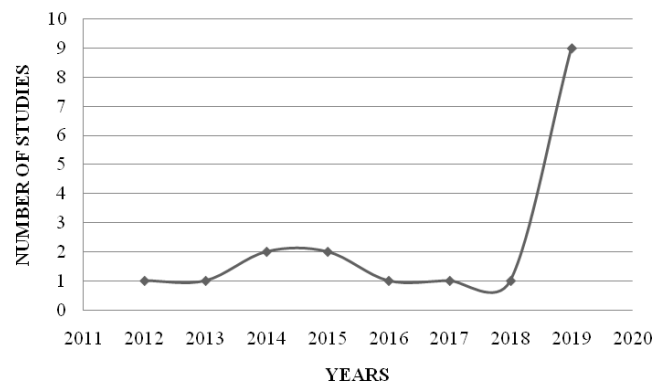
TABLE 3. (Continued.) Previous applications and scientific studies on smart cities.

Elsaeidy et al. [120]	2019	Smart city infrastructure	Restricted Boltzmann Machines (RBMs)	Ability to learn high level features from raw data in an unsupervised manner and handle real data representation generated from smart meters and sensors.	Inherits security problems, and threats specifically come from cyber-attacks and DDoS attacks
Nilssen [121]	2019	Smart urban innovation	Analytical model	N/A	N/A
Desdemoustier et al. [122]	2019	Smart governance	Data collection and a typology of municipal understandings.	N/A	The study cannot claim to officially represent the complexities of understanding in municipalities.
Cilia et al. [123]	2019	Smart transportation	Wireless Dynamic Sensor Network (WDSN)	Useful to determine the location between nodes in smart cities.	Different obstacles that can block the line-of-sight signals and environmental effects
Dameri et al. [124]	2019	Smart urbanization	Qualitative Data Analysis	Useful for practitioners	The study does not address some beyond scope topics but is interesting for future studies
Sepasgozar et al. [125]	2019	Smart urbanization	Urban service technology acceptance model (USTAM)	Provides both theoretical and empirical support to the project to implement smart cities in developing countries	N/A
Abbate et al. [126]	2019	Smart business, smart technology	Fuzzy set qualitative comparative analysis (fsQCA)	One of only handful studies that focuses on Business Model (BM) go beyond the single case study, thus offering many opportunities for further research.	The limited sample of the current study did not permit any further statistical testing for fuzzy analyses

cultural facilities while providing a zero-carbon, energy-efficient and self-sufficient city.

Another example produced by the collaboration of Sea Steading Institute and Delta Sync [128] and an overview of the design is presented. In this project, the most significant aspects include sea keeping, safety, mobility, water experience, dynamic geography, and growth. For each mentioned aspect, the pros and cons were discussed in the project report. Moreover, the preferences of these aspects were made, and unfeasible and feasible options were discussed.

In the study by Kiritmat *et al.* [127], a floating settlement concept was developed using parametric modeling techniques in combination with Intelligent Decision Support tools and optimization methods. The results of two optimization algorithms NSGA-II (Non-Dominated Sorting Genetic Algorithm-II) and DE (Differential Evolution) were compared based on the objective functions considered in the research. The objective functions of the study were

**FIGURE 6.** The number of studies between 2012 and 2019 in Table 3 based on ISI WOS.

walkability in the floating settlement, scenic views both from the floating settlement and Urla and the cost-effectiveness of the floating structures. The problem was defined as finding

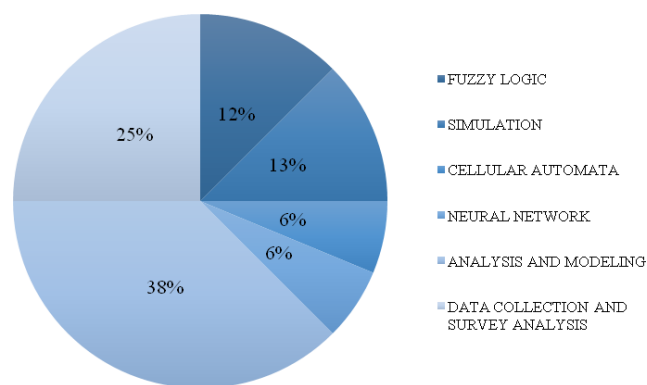


FIGURE 7. The frequency of proposed methods in the ISI WOS studies from Table 3.

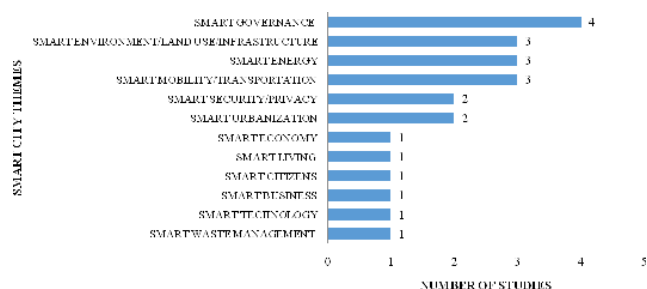


FIGURE 8. The number of prominent smart city themes in the ISI WOS studies from Table 3.

a good distribution of residential, agricultural, green and public areas considering these objective functions. As a conclusion of this study, optimization results of the two algorithms, namely, NSGA-II and DE, were compared within the Pareto graphs. Moreover, the identification of good configurations of functions in a floating settlement was made using multi-objective optimization methods.

Furthermore, the extension of this research, namely, as “Evolutionary Algorithms for Designing Self-Sufficient Floating Neighborhoods”, was proposed by Kirimtat *et al.* [129]. In addition to the previous study, the authors compared two different evolutionary algorithms, including a self-adaptive real coded genetic algorithm (CGA) and CGA-DE (differential evolution version), in the context of developing a self-sufficient floating neighborhood. According to this study, computational tools could be beneficial methods that can easily tackle the complexity of floating neighborhood design.

Kirimtat and Krejcar [130] presented a study on the development of self-sufficient floating cities with renewable resources. According to one statement in this research, the floating city concept has become urgent and gained popularity across the world due to land shortage for building constructions in urban areas. Therefore, designing a self-sufficient floating city is a novel approach that has been limitedly studied in the literature. However, one example of this approach is reported in the literature in [127]. According to this article [129], the applications, research, and development of urban city designs that were previously studied in

the literature were presented as possible adaptations of these strategies into floating city projects.

In the study by Cubukcuoglu *et al.* [131], computational intelligence techniques were applied to the conceptual design of floating settlement. In this paper, the problem was described as a multi-objective constrained real parameter optimization problem. There were three objective conflicting functions: accessibility between urban functions, wind protection, and maximization of visibility. A multi-objective harmony search algorithm was compared to the Differential Evolution algorithm.

Another study by Zanon *et al.* [132] dealt with the floating urban development concept and analyzed the flood risk and population growth in the port cities. In this article, the integration of urban and ecosystem development with food and energy production was also discussed. The coastal cities that were the focus of this article began to test medium- and large-scale concepts. Then, a large-scale floating maritime project was presented in this research.

Levi *et al.* [133] developed an optimization model for the artificial floating island that is composed of Very Large Floating Structures (VLFs). In this study, the optimization model addressed the geometric shapes on the island, namely, the array of floating platforms. The land-use layout and transportation network also focused on this research. A bilevel optimization problem was formulated regarding the land-use layout and the transportation network. Different modifications of the Genetic Algorithm were developed to obtain Pareto front approximations.

Due to the land scarcity problem in the coastal cities across the world, Wang *et al.* [134] proposed the preliminary and sustainable design of Modular Floating Structures (MFS) by focusing on structural and safety aspects and by shedding light on the other issues, such as dwelling feasibility and occupant comfort. This research also combines two different disciplines, namely, naval architecture and civil engineering, which are not generally linked in the existing literature, to overcome this novel challenge.

Table 4 was created by making correlations between the previous floating city studies and smart city themes. It shows the basic approaches given in the floating city projects, therefore we found connections between smart city themes. For instance, in the study of Kirimtat and Krejcar [130], the integration of the self-sufficiency approach with renewable energy resources into floating cities could be related to smart energy theme, since both of ideas deal with energy point of view. Also, another study by Levi *et al.* [133] carried out a different approach in terms of transportation efficiency, and this could be related to smart transportation within the city.

Ullah *et al.* [135] proposed energy- and congestion-aware routing metric for smart meter networks for use in smart city applications. The recommended metric has an adaptive parent node selection mechanism by considering the residual energy and queue utilization of neighboring nodes. By minimizing power consumption and enhancing lifetime network, this method could be applied to floating city concepts given its

TABLE 4. Correlation between floating cities and smart city themes in the previous studies.

Year	Approach	Smart City Theme	Author(s)
-	Safety	Smart security	Delta Sync [128]
2015	Walkability	Smart transportation	Kirimtat <i>et. al.</i> [127]
2019	Walkability	Smart transportation	Kirimtat <i>et. al.</i> [129]
2018	Self-sufficiency	Smart energy	Kirimtat and Krejcar [130]
2016	Accessibility	Smart transportation	Cubukcuoglu <i>et. al.</i> [131]
2020	Food and energy production	Smart energy	Zanon <i>et. al.</i> [132]
2019	Land-use layout and transportation network	Smart environment, smart transportation	Levi <i>et. al.</i> [133]
2019	Dwelling feasibility and occupant comfort	Smart building, smart people	Wang <i>et. al.</i> [134]

ability to adapt to various topologies. Moreover, by conducting a series of simulations, significant network performance among floating neighborhoods would be achieved.

Another study by Tawalbeh *et al.* [136] stated that smart cities are the core ingredient of urbanization and urban development; thus, they should be the first aim for whole cities across the world although they are placed on the sea. Additionally, according to the authors, smart cities should use the power of data and sensors to easily manage the cities themselves. The area of their research is mainly based on the organization and the optimization of handheld device applications and their power consumption. Such location-based applications could also be used in smart floating cities. Mathematical models could be developed and experiments could be performed for use in the design of smart floating cities.

Sivrikaya *et al.* [137] presented a methodology in their research by transforming the complex smart city concept into a structured model to develop a dynamic and adaptive ecosystem in the digital cities of the future. Three significant aspects are identified in this study, including a functional description of city objects and physical devices, a distributed service directory and planning of these tools. By improving the adaptive ecosystem of future smart floating cities, these aspects could be adapted easily to increase the functionality of services in smart floating cities.

Brisimi *et al.* [138] used machine-learning algorithms as an approach for classifying roadway obstacles in smart cities. A smartphone application called Street Bump was additionally created to combine novel metrics of obstacle irregularity, and they experimented in the City of Boston to demonstrate the feasibility and effectiveness of the proposed system. This application could be implemented in a smart floating settlement to design a floating city that lacks roadway obstacles.

The review study by Cui *et al.* [139] discussed the multiple security and privacy requirements in smart cities. Based on

this research, more reasonable and effective protection methods should be developed compared with existing methods, and these methods include IoT-based network security, security and privacy issues in fog-based systems, user-centric and personalized protection methods, data minimization, lightweight security solutions, and theoretical complement. These security and privacy protection methods should also be used in smart floating cities since humanity will move to the sea to survive in the future.

Corte and Sørensen [140] discussed the optimization of water distribution network design, which is a combinatorial optimization problem, in their article. Although it is a complicated optimization problem because it has discrete decision variables and nonlinear cost function and constraints, this could be implemented to address smart floating city problems to manage the water distribution network within the city.

In several studies of Sanchez and his team [141]–[145], SmartSantander is presented as a unique and city-scale experimental research facility to support smart city applications and services. Basically, SmartSantander has some targets as an architectural reference model for open real-world IoT experiments; a scalable, diverse and trustable large-scale real-world experimental facilities; implementation of cases for the experimental facility; and lastly a huge set of future internet experiments. As a conclusion, the authors believe that SmartSantander should maintain its unique platform for future projects.

In their study, Sanchez *et al.* [143] presented OrganiCity's implementation of the EaaS framework which concerns a toolset allowing for development, deployment, and evaluation of smart city solutions. Regarding an IoT infrastructure, this was the first offered and integrated toolset.

As urban systems are high potential scenarios for integrating novel services and technologies, city managers and stakeholders have started to introduce the use of internet technologies for the improvement of sustainability of the buildings. Therefore, IoT technologies provide improvement in the connection of city ecosystems across the world. Taking advantage of massive amounts of information is also aimed at these improvements [147], [148].

VI. CONCLUSIONS

As sea levels are increasing every day, cities below sea level (such as most cities in the Netherlands), are facing a significant challenge, and they are trying to find an alternative solution that could overcome the problem of approaching sea currents [127]. Floating cities or settlements have emerged as a novel concept due to climate change, rising sea levels, and land shortage. The concept could also be considered as an opportunity for social and political alteration [127]. Oceans are not under the control of any government, and each human has the right to use these alternative living spaces. Thus, oceans are our last chances to survive on earth [149].

Crowded locations across the world, especially in the seafront areas, are becoming increasingly crowded due to heavy traffic and inconvenient environmental facilities.

Therefore, floating settlements represent an alternative solution to these challenges. Moreover, the latest examples of small floating structures by the petroleum industry have shown that this novel concept is quite suitable and applicable for any climate across the world based on economic reasons [149].

Taking smart and sustainable city principles in the account, we also try to develop a novel concept, namely, “smart floating cities”, via inspiration from the smart city themes and possibly implementing them into the floating city concept. Thus, the future smart floating cities could be self-sufficient regarding energy issues and access to each function. In addition, floating cities should have smart citizens who benefit from these aspects and be environmentally friendly. Moreover, the multi-objective optimization techniques could be implemented in the design of floating settlements based on the current literature.

Given the global spread of the smart city and floating city concepts, the utilization of smart city concepts in floating settlements would be a primary alternative for future studies. In the previous sections, the most important smart city themes and previously proposed methodologies in the existing literature were highlighted. Next, we focus on and discuss recent applications, studies, future developments, and possible contributions to smart floating cities.

Smart and sustainable city concepts should contain some keywords as mentioned in the preliminary sections of this research, and these terms include transportation, land use, environment and their relation to each other [127]. The ideal smart city structure should be balanced. Furthermore, there is no single answer for creating the perfect combination of aspects that constitute a smart urban city. These aspects depend on the size of the city, accessibility to other cities, and accessibility to service centers. Therefore, the role of the designer is to aggregate these factors by taking population size and suitable functions into consideration [150]. In the literature, researchers studied the interaction between transportation and land use in a detailed manner. For instance, in the study by Hall [151], the connection between transportation and land use was discussed, and the evaluation of this connection should be made. In addition, researchers should provide critical integration. Another study by Newman and Kenworthy [152] focused on the challenge of protecting personal independence while locating land areas in the city center and supplying transportation to the city center. Moreover, providing clean air standards, secure streets and appealing public squares are also important.

The main goal of this research was to raise awareness of the scientific community about the current state of the smart city concepts revealing its key future trends, including floating cities exploiting IoT technologies and applications. We also presented the recent advances of previous studies and the possible implementation of previous methods in future studies on different smart city concepts. The existing literature provides various studies with different methodologies by highlighting

several smart city key themes from the Web of Science. In this study, we analyzed these smart city key themes by reviewing 500 articles to understand the main relationships among them by indicating application examples. We performed detailed searches in Web of Science using the keywords “smart city” and “concept”. 155 items, 2 clusters, and 8034 links were extracted in total from the network visualization based on the 500 articles found in Web of Science (including 224 articles, 228 book chapters, and 58 review papers).

By performing a detailed selection of these search results we found 153 corresponding articles for detailed analysis out of the 500 candidates found in the literature. We revealed that there is an ongoing trend for implementing various smart city themes, especially in 2019 compared to previous years. We also reviewed modeling and analysis studies and found that modeling techniques could be used for simulation studies on smart cities.

We also concluded that based on current developments in scientific studies, there is still a lack of scientific reports on smart floating cities, which seems to be good candidates for future smart cities. The implementation of smart city key themes and methods could be taken into consideration for the floating settlements by using different data management technologies, such as IoT, Big Data and Cloud Computing, and also some heuristic methods [153]. Furthermore, multi-objective real parameter optimization techniques could be used for the conceptual design of smart floating cities given that a few examples of the implementation of this method for the design of floating settlements are available. Given the high potential of designing smart floating settlements, they can be the future smart cities of the world.

We believe that this research is useful for readers because it revealed the need for integration of different research areas and different data management methods for creating future smart cities, including Big Data, Cloud Computing, and IoT.

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