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*Review*

# Big Data-Driven Urban Management: Potential for Urban Sustainability

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**Abstract:** With the world's rapidly growing urbanization, urban sustainability is now expected for urban life. Due to this rapid growth, meeting the emerging challenges for urban management and sustainability worldwide is challenging. Big data-driven technologies can be an excellent solution to address these upcoming challenges. Therefore, this study explores the potential of big data technologies for ensuring sustainability in urban management. The study conducted a systematic literature review guided by PRISMA (preferred reporting items for systematic review and meta-analysis) on publications over the last 21 years. The study argues that urban management is an integrated function of public and private agencies to address the significant challenges of urban life and to develop the city as more competitive, habitable, and sustainable. Urban management can utilize big data analytics (BDA) for digital instrumentation, data-informed policy decisions, governance, real-time management, and evidence-based decisions. Urban sustainability can ensure the smooth operation of urban affairs through strategic planning under three major dimensions: social, economic, and environmental. Big data technologies can ensure smart transport, traffic, waste management, energy, environment, infrastructure, safety, healthcare, planning, and citizen participation in regular urban affairs to provide a better urban life. This study develops several indicators that will be helpful for concerned stakeholders in policy, planning, designing, and implementing sustainable urban development.

**Keywords:** land use; urban green space; urban life; urban governance; urban policy; land reform

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## 1. Introduction

With increasing technological growth, people across the globe are choosing to live in urban areas. The United Nations (UN) report that approximately 54.5% of people worldwide live in urban areas [1]. The rate of citizens living in urban areas will increase to 60% by 2030 globally [1]. By 2030, cities with over one million people will number 662 in the world. In 2016, the total number of megacities was 31 comprising over 10 million inhabitants, but by 2030, this will rise to 41. Maintaining the urban area and providing people with a pleasant urban life is a difficult challenge without the support of advanced technology, such as big data analytics (BDA). A smart city powered by big data is a timely solution for coping with these emerging challenges [2].

Although the urban planning and management sector is developing to better address the 21st century's challenges, other facets of human understanding are also growing [3]. The present Fourth Industrial Revolution emphasizes significant scientific and technical breakthroughs [4], disruption in numerous industries [5], and the rise of the everyday use of big data-based smart devices [6]. The Internet of Things (IoT) is a set of uniquely addressable, heterogeneous electronic devices that gather and exchange information through nominal human contacts [6], producing billions of facts worldwide every day [7]. It renders modern tools across different scales and quickly transforms them into the form of software commands for urban planners to connect [8].

Traditional urban design and management strategies are increasingly approaching their limits with the growing complexity of universal cities in the current information age [9]. Traditionally, urban management could depend on traditional approaches that engaged only a minimal number of people and stakeholders for appropriate decision-making [10]. Therefore, urban planners must use the power of emerging technologies such as BDA to make high-quality [11], evidence-based decisions across spatiotemporal scales [12]. However, its key challenges are linked to the need for an appropriate understanding of data mining procedures, and the processing, analysis, and use of these enormous data sets [13].

Over more than four decades, sustainable cities have become the world's foremost pattern of urbanism [14]. People are seeking to achieve optimum sustainability in the built environment through processes that lessen resource usage, reduce energy use, mitigate emissions and decrease waste, and enhance social justice and well-being [15]. Indeed, many recent studies and UN policy documents argue that appropriate urban management positively impacts resource productivity [16]; climate change; monetary growth; social mixing and solidity; citizens' health and urban life quality; and cultural elements [17]. In short, global, national, and local policies support sustainable urbanism as the most favored solution to the problems of sustainable growth [18]. It is contended that all the advantages of sustainability can be accomplished by appropriate strategies, providing safe livable human environments combined with nominal resource requirements [19] and, thus, fewer ecological impacts [20].

Various alternative and modern styles of planning, constructing, maintaining, and governing towns that rely on cutting-edge information communications technology (ICT) are occurring [14] and are quickly emerging in this setting of the dynamic challenges of development and urbanization [21]. This paves the way for sustainable cities to improve and boost their efficiency in terms of sustainability [22]. Owing to ICT's immensity, awareness is growing that its vast but untapped potential can solve many challenges related to socioeconomic and environmental issues. Advanced ICT can provide a promising solution to the emerging barriers to sustainability and urbanization [23]. In particular, big data technologies and related tools are compatible with smart city and urban management approaches to improve urban sustainability [24]. A new age is emerging in the practices of sustainable urbanization. A smart city, powered by data, offers sustainable urbanism, with a deliberate movement established for sustainable cities worldwide to be more innovative. Urban sustainability can be achieved by designing and employing data-driven technology systems to strengthen and optimize the related processes, functions, facilities, architectures, tactics, and policies concerning different urban patterns [14]. Big data-based approaches have become essential for the operation of smart urban matters in the spirit of sustainability [25]. Consequently, we are moving into an age in which instrumentation, data, and computation systematically pervade the structure of cities. Modern cities use new technology, especially IoT [26] and BDA [24], to promote sustainable growth.

Science-focused technology is well matched with the plan to imagine alternative futures. Science and technology developments ultimately carry comprehensive visions of how to grow urban areas in the future and of the possibilities and risks that the future will bring [18,27]. Advanced technological integration is therefore necessary to achieve the expected data-driven sustainable urban management (SUM) [28]. It is now time to ensure planning for sustainability [10]. When forming strategies, sustainable cities need to be driven by a long-term plan stemming from the major trends that are transforming our society at a rising pace, specifically, sustainability, urbanization, and data-driven technology [22]. Sustainable cities worldwide have accepted the need to strive towards goals that stretch well into the future by identifying a connection between these developments; thus, they have formulated several strategies to attain these goals [29].

Many published studies already cover urban management [21,30]; urban planning [10,31]; the smart city [32,33]; urban development [8,34]; and urban sustainability [24,35–37]. However, a key focus is still lacking on the potential of big data technologies for urban management and urban sustainability. This study, therefore, explores the potential application of BDA for urban management with sustainability. To address this objective, the study is guided by two research questions: (1) what are the main components of urban management that ensure urban sustainability, and (2) how can big data analytics (BDA) be integrated in a holistic way to achieve sustainable urban development? The study explores many indicators to present the urban sustainability issue under an approach driven by big data, with this helpful for urban planners, administrators, and related stakeholders to ensure sustainable urban development.

The paper is organized into five sections. The first, second, and third sections describe the introduction, methodology, and results, respectively. The fourth and fifth sections present related discussion and the conclusion.

## 2. Methodology

### *2.1. Research Design*

This study used a mixed-methods approach, which included a systematic review of the literature to identify the most pertinent documents and a narrative review to describe the major results in the selected documents. This synthesis includes the evaluation of a huge and diverse body of literature on the issue, as well as the integration and synthesis of multiple academic, scientific, and technical fields. This review and synthesis are methodological in nature, having been structured, defined, and carried out in line with PRISMA (preferred reporting items for systematic review and meta-analysis) [22].

### *2.2. Interdisciplinary Approach for Data Extraction*

The interdisciplinary approach has become a popular strategy for researching various subjects, as evidenced by an increasing number of academic publications [38]. Because of the nature of its technical and social sciences integration, SUM is essentially multidisciplinary and transdisciplinary [39]. This also applies to any review and synthesis, which will be interdisciplinary as they will incorporate insights and approaches from several disciplines or will involve multiple disciplines in a single concept [18]. Interdisciplinary attempts to build theories for adapting to changing situations continue to have a limited impact. Multidisciplinary, interdisciplinary, and transdisciplinary viewpoints and approaches are required for SUM research. To ensure the validity and use of the study's findings, all methodologies require conceptual correctness.

### *2.3. Development of a Research Protocol*

This study has been scientifically guided by the developed research protocol (Table 1). The study conducted a systematic review that was published over 21 years. The BDA has improved a lot in the last 21 years that played a vital role in ensuring urban management and sustainability sector. So, this study selects the time span. Comparatively recent studies were emphasized for the argument regarding the potential BDA application for SUM. The study also attempts to focus on a new paradigm of data-driven urban management that will help to ensure urban sustainability.

**Table 1.** Summary of the research protocol.

| Items | Explanation |
|---|---|
| Used databases | Web of Science, Engineering Village, Scopus, and ScienceDirect |
| Criteria for publication | Only peer-reviewed journals |
| Language | Articles published in English |
| Span of search | From 1 January 2001–15 January 2022 |
| Search keywords | Urban management, city, big data, BDA, sustainability, sustainable development |
| Fields of search | Title, abstract, and keywords |

**Table 1.** *Cont.*

| Items | Explanation |
|---|---|
| Inclusion criteria | The article should focus on big data, urban management, and sustainability |
| Exclusion criteria | Not full text, and duplication and/or publication in languages other than English. Articles are also excluded if their content does not cover big data, urban management, and sustainability. |

### 2.4. Search Strategy

In general, literature reviews aid in the development of a new subject of study. They generally provide an opportunity to examine, synthesize, and focus on prior studies in order to uncover new knowledge that might aid in the development of a new educational and research paradigm. In the current study, an extensive systematic review has been done with PRISMA guidance [40]. This study widely searched in several popular databases, such as the Web of Science, Engineering Village, Scopus, and ScienceDirect, using a few keywords, for example, "urban management," "city," "planning," "big data,' and "sustainability." The study was conducted in October 2021, with strategy strings as shown in Table 2.

**Table 2.** Research databases and keyword search string.

| Databases | Search String |
|---|---|
| ISI Web of Science | TS = (city * or urban * or management * or big data * AND sustain *) |
| Engineering Village | City, urban management AND big data AND sustainability |
| Scopus | City, urban management AND big data AND sustainability |
| Science Direct | City, urban management AND big data AND sustainability |

### 2.5. Inclusion and Exclusion Criteria

The most relevant papers were chosen using predefined inclusion criteria. The main criteria were: (a) is the highlighted article on urban management and big data? and (b) is it focused on urban sustainability? The study excluded articles published in languages other than English, those without full text, and those that did not exactly focus on the desired issues.

## 3. Results

### 3.1. Selection of Documents

This study was mainly guided by PRISMA checklists (Supplementary Table S1). The major steps of the PRISMA approach are identification, screening, eligibility, and inclusion. In the first step (identification), 756 documents were identified from the cited sources, along with another eight. The first search result retrieved all kinds of documents, such as conference papers, journal articles, books, and book chapters. In the screening stage, however, all documents were eliminated except for journal articles. As a result, the search was restricted to "article types" and "keywords," thus allowing the removal of working documents, books, conference proceedings, and magazines. In all, 651 documents were removed after the abstract screening. In the eligibility stage, 113 documents were obtained by removing 82 documents by following the inclusion criteria. It is worth noting that every paper published on the ISI Web of Science was also included in the other databases, namely, Engineering Village, Scopus, and ScienceDirect. In the inclusion stage, 31 quality documents were selected comprising original journal articles that could be used to explain the potential application of BDA for SUM (Figure 1).

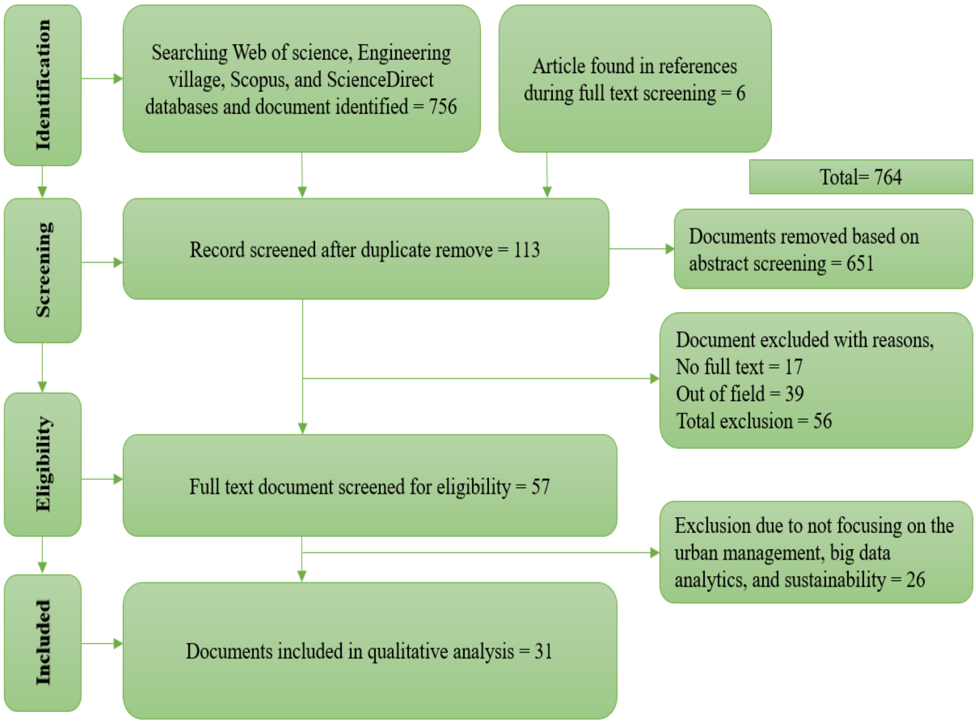


**Figure 1.** Document selection guided by PRISMA approach.

### 3.2. Word Clouds for Data-Driven Urban Management and Sustainability

The study conducted an extensive review of the data-driven urban management and sustainability literature. The aim of generating word clouds was to show a concise picture of data-driven urban management and sustainability. The VOSviewer software tool was used to construct the word clouds. The phrases are used most frequently in data-driven urban management and sustainability (Figure 2). Data extracted from the articles demonstrated each term co-occurring a minimum of three times.

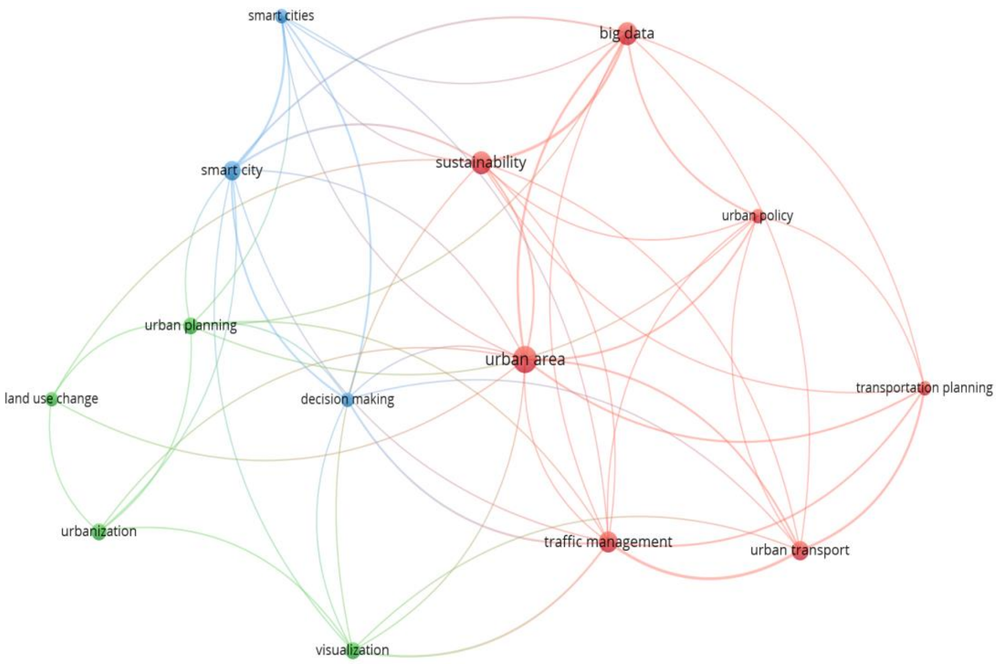


**Figure 2.** Map of word clouds on data-driven urban management.

### *3.3. Analytical Results*

#### 3.3.1. Major Dimensions of Data-Driven Urban Management

This study reveals 10 major components of data-driven urban management from the existing literature, namely, smart transport, smart traffic, smart waste management, smart energy, smart environment, smart infrastructure, smart safety, smart healthcare, smart planning, and citizen participation. Although all selected documents do not agree with all components, the findings reflect the agreement of most studies due to their representativeness. Most scholars highlight these 10 components and recommend that data-driven technologies play a vital role in achieving sustainable urban development (Table 3).

**Table 3.** Key dimensions of data-driven urban management.

| Urban Management Characteristics | Cited Sources |
|---|---|
| Smart planning | French et al. [41], Hao et al. [42], Morioka et al. [43], Pan et al. [44], Kharrazi et al. [45], Bibri and Krogstie [46], Nathali et al. [47], Madu et al. [35], Glaeser et al. [48], Silva et al. [49], Sörensen et al. [50] |
| Smart transport | He et al. [51], Wang et al. [24], Mans [30], Ivanov and Gnevanov [31], Du et al. [52], Bibri [53], Ersoy and Alberto [54], Kong et al. [55], Yang [38], Bibri and Krogstie [14], Milojevic-Dupont and Creutzig [12], Zhang and He [56], Bibri [57], Engin et al. [21] |
| Smart traffic | Morioka et al. [43], Ivanov and Gnevanov [31], Glaeser et al. [48], Silva et al. [49], He et al. [51], Wang et al. [24], Mans [30], Ivanov and Gnevanov [31], Du et al. [52], Bibri [53], Ersoy and Alberto [54], Kong et al. [55], Yang [38] |
| Smart waste management | D'Amico et al. [58], Morioka et al. [43], Pan et al. [44], Kharrazi et al. [45], Bibri and Krogstie [46], Nathali et al. [47], Madu et al. [35], Glaeser et al. [48], Silva et al. [51] |
| Smart energy | Wang et al. [24], Du et al. [52], Bibri [53], Ersoy and Alberto [54], Kong et al. [55], Yang [38], Bibri and Krogstie [14], Zhang and He [56], Bibri [57] |
| Smart environment | Jararweh et al. [59], Ersoy and Alberto [54], Kong et al. [55], Yang [38], Bibri and Krogstie [14], Zhang and He [56], Bibri [57], Engin et al. [21] |
| Smart infrastructure | Bibri [53], Bibri and Krogstie [46], Nathali et al. [47], Madu et al. [35], Glaeser et al. [49], Silva et al. [49], He et al. [51], Wang et al. [24], Mans [30], Ivanov and Gnevanov [31], Du et al. [52] |
| Smart safety | D'Amico et al. [58], Kandt and Batty [60], He et al. [51], Wang et al. [24], Mans [30], Ivanov and Gnevanov [31], Du et al. [52], Bibri [53], Ersoy and Alberto [54], Kong et al. [55] |
| Smart healthcare | D'Amico et al. [58], Hao et al. [42], Morioka et al. [43], Pan et al. [44], Kharrazi et al. [45], Bibri and Krogstie [46], Nathali et al. [47], Madu et al. [35], Glaeser et al. [48] |
| Citizen participation | Wang et al. [24], Engin et al. [21], Bibri [53], Ersoy and Alberto [54], Kong et al. [55], Yang [38], Bibri and Krogstie [14] |

Note: Multiple responses cited from the same source whenever applicable.

#### 3.3.2. Relationships between Urban Management and Urban Sustainability

The current study has explored many key indicators under the major dimensions of urban sustainability (social, economic, and environmental dimensions) from the existing literature. In terms of interaction between these dimensions, strong synergy is found for achieving smooth urban management along with urban sustainability (Table 4).

**Table 4.** Summary of relationships between urban management and urban sustainability.

| Major Dimensions | Key Indicators | Key Influences | Sources |
|---|---|---|---|
| Social dimension | Social justice | • Minimization of socio-economic gap between rich and poor<br>• Available accommodation for all<br>• Ensuring citizens' access to public services<br>• Affordable housing and food | Zhang and He [56], Thakuriah et al. [61], Zhang et al. [62], Bibri [22] |
| | Quality of urban life | • Availability of places for people's interaction<br>• Ensuring access to playgrounds, parks, and other recreational places<br>• Ensuring safety and social security | Bibri [57], Silva et al. [49], Bibri and Krogstie [23] |
| | People's participation | • Easy access to social work<br>• Ensuring participation in decision making<br>• Empowerment for community representation | Du et al. [52], Palumbo et al. [63] |
| Economic dimension | Average income | • Ensuring that the average income of the household meets the minimum requirements of the family<br>• Ensuring job opportunities | Bibri [53], Middel et al. [64] |
| | Affordability | • Ensuring affordability of basic services | Ersoy and Alberto [54] |
| | Access to food and nutrition | • Ensuring access to food and nutrition<br>• Caring for children, and for those who are old and those who have disabilities | Madu et al. [35] |
| | Access to finance | • Ensuring access to finance for under-privileged groups of urban citizens<br>• Promoting businesses through bank loans<br>• Ensuring collateral-free finance for the urban poor | Glaeser et al. [48], Xiao and Xie [65] Deng [16], Pan et al. [44] |
| Environmental dimension | Urban green space | • Establishing green parks, lawns, community gardens, and green playgrounds<br>• Green plantations in streets and walkways<br>• Rooftop gardens<br>• Landscaping in community and office premises | Silva et al. [49], Jia and Zhang [66] Sörensen et al. [50], Ye et al. [67] |
| | Sustainable transportation | • Public transportation facilities, such as trains, buses, etc.<br>• Renewable energy-based vehicles<br>• Smart transport system<br>• ICT-based tracking management<br>• Smart traffic management. | He et al. [51], Kong et al. [55], Silva et al. [49], Sai and Wang [68] |
| | Waste management | • Smart system for collecting waste<br>• Disposal system for waste<br>• Smart drainage and sewerage system<br>• Smart cleaning system<br>• Pollution control | Bibri [53], Bibri [39], Feroz et al. [18], Liu et al. [69], Zhang et al. [70] |
| | Energy management | • Local renewable energy production system<br>• Social energy management<br>• Low greenhouse gas (GHG) emissions | Ersoy and Alberto [54], Yang [38] |

#### 3.3.3. Urban Big Data Sources

Big data are essential for accelerating appropriate development. Through using BDA, the development pattern worldwide has now changed. As BDA provide a clear continuous development process, drawbacks, and loopholes in particular activities of different organizations can be avoided [60]. In particular, BDA are more applicable and significant for addressing sustainable urban development issues. Furthermore, big data make a considerable contribution to properly maintaining the capabilities of various sectors concerning urban development [71]. Table 5 presents the pivotal big data sources, such as public sources, individual sources, and sensor devices. More specifically, big data can be found in various other sources including government websites, private agency websites, social media networks, public transport systems, waste management systems, etc. [72]. Basically, these sources are continually being used in the development and maintenance of various sectors, including the sustainable and ultimate prosperity of urban development.

**Table 5.** Sources of urban big data.

| Major Sources | Identified Specific Data Sources | Sources |
|---|---|---|
| Public sources | • Various government websites<br>• Private agency websites<br>• Open repositories<br>• Transactions in the banking system<br>• Surveillance systems | He et al. [51], Kong et al. [55], Bibri [39], Kaginalkar et al. [73], Engin et al. [21], Bibri and Krogstie [46], D'Amico et al. [58], Xiao and Xie [65] |
| Individual sources | • Social media network<br>• Information from internet access<br>• Information from mobile access<br>• Information from internet service providers (ISPs) | French et al. [41], Bibri [53], Ersoy and Alberto [54], Sörensen et al. [50], Bibri and Krogstie [14], Anthopoulos and Kazantzi [74] |
| Sensor devices | • Information from road traffic system<br>• Public transport system<br>• Closed circuit television (CCTV) camera<br>• Community entrance auto-detection system<br>• Waste management system | He et al. [51], Šoštarić et al. [75], Ersoy and Alberto [54], Yang [38], Sai and Wang [68], D'Amico et al. [58], Xiao and Xie [65], Bibri [39], Dong et al. [27], Liu et al. [69], D'Amico et al. [58] |

#### 3.3.4. Role of BDA for Urban Management and Sustainability

Table 6 presents the role of BDA in sustainable urban management, where big data can make a substantial contribution to the myriad sectors of smart cities. For instance, BDA influence smart planning; smart transportation and traffic; smart waste management and the environment; smart healthcare; as well as other areas. Therefore, big data and urban development management are intertwined, with urban development not possible without suitable linkages between these two aspects if sustainable urban development is to be achieved.

**Table 6.** Role of BDA in sustainable urban management.

| Key Dimensions | Application of Big Data | Sources |
|---|---|---|
| Smart planning | Big data are usually used for smart planning and better delivery of public services. | Silva et al. [49], Bibri and Krogstie [14] |
| Smart transport | Big data make it easier to find the simplest form of transport. | Silva et al. [49], Zhang and He [56] |
| Smart traffic | Automated traffic systems can be developed by using big data technologies. | Morioka et al. [43], Ivanov and Gnevanov [31] |
| Smart waste management | Smart waste management can be ensured through big data. | D'Amico et al. [58], Silva et al. [49] |
| Smart energy | Renewable energy can be produced and distributed smoothly by using big data. | Wang and Moriarty [24], Kong et al. [55] |
| Smart environment | Big data protect the atmosphere and control resources by pollution elimination. | Jararweh et al. [59], Bibri and Krogstie [14] |
| Smart infrastructure | Urban infrastructure can be developed by using big data. | Bibri [53], Silva et al. [49] |
| Smart safety | To establish appropriate urban planning, BDA ensure good healthcare, better education, safety, and security, and better tourism facilities. | D'Amico et al. [58], Kandt and Batty [60] |
| Smart healthcare | Data-based healthcare services can be ensured through big data. | D'Amico et al. [58] |
| People's participation | Members of the general public have the opportunity to participate in and add their opinions to achieve sustainable urban development. | Wang and Moriarty [24], Engin et al. [21] |

## 4. Discussion

### 4.1. Urban Management through Big Data Analytics (BDA)

#### 4.1.1. Digital Instrumentation

Globally, the BDA revolution is emerging as a way to achieve sustainable urban management and smart cities [57]. Sustainable cities are conceptualized as tools for measurement and control on multiple spatial scales connected through various networks with intelligence. They can deliver and synchronize continuous data about multiple facets of urbanity and socioeconomic forms of sustainability [22]. Objective, real-time analytics of city life and infrastructure and the possibility of fundamentally diverse kinds of social organization are enabled by the instrumentation of these cities. The ICT industry's realm provides the detailed devices and software necessary to operate the operating system for smart sustainable cities [39]. This infrastructure encompasses integration, data collection and analysis, decision making, practice refinement, and service delivery, with a focus on sustainability and inclusive urban life [76].

#### 4.1.2. Data-Informed Policy Making

Although BDA provide a vast opportunity for making accurate data-based decisions, at times, the use of BDA entails the risk of drawing incorrect conclusions, for example, by making assumptions about the causes of violence based on public data sets that are not applicable to a particular place [57]. On their own, BDA cannot simulate the complex picture of possible connections between multiple policy domains, such as crime and social groupings in specific neighborhoods. Scholars are unconvinced about universal urban experiences, emphasizing the importance of contextual specificities and local experiences within specific places [77]. As a result, findings established in high-crime areas do not immediately apply to sites with comparable statistics but distinct local contexts. However, as data are increasingly being employed, the difficulty is to establish a suitable balance between automated analysis and contextual interpretation [30].

#### 4.1.3. Policy Governance

When data-driven information is used, political impediments are manifested in two ways. Firstly, data might reveal findings that are unsettling to political players. A city may be unwilling to cooperate with data collection activities if these intended operations are linked to territories controlled by the political opposition or if the data collection initiatives are characterized as anti-government campaigns [30]. Additionally, coordination across political constituencies may prove challenging. Underpinning this relationship is the concept of trust–faith in the government's ability to use the data effectively and trust in local stakeholders. As cities move toward more data-driven policies, stakeholders will need to discover practical strategies to build mutual trust [46]. Advances in data-driven innovation must translate into workable forms of urban policymaking and must illustrate how collaboration between diverse actors can be facilitated from the start to avoid ineffective technology and policy designs [54]. Policy governance must be developed to strengthen decision making regarding which policies to adopt and when to exercise caution when implementing data-driven procedures [65]. From a research viewpoint, future studies should shed light on the interaction between the collection of new, more precise data and the political ramifications that may result [74]. To overcome future challenges, each city's various stakeholders must work together and pay close attention to the time and conditions surrounding the development of data-informed policy.

#### 4.1.4. Real-Time Management

The significant influence of data sources and technology can provide actionable knowledge in real-time for diverse city tasks and services [49]. While precise real-time data promote interoperability, they also encourage effective monitoring, involvement, and rule of services and public records. A "nowcasting" concept enables accurate short-term forecasting to manage and analyze population flows and local government service needs [49].

Additionally, online and social media data can provide vital real-time insights into the public mood in response to current events [78]. The most extensive and highest quality urban data, for instance, in relation to transportation and mobility, make the subject highly suited for real-time testing of services [73]. Furthermore, a city dashboard could be developed to collect real-time data from visitors to make real-time decisions [58]. However, the dashboard could be quite patchy, as it collapses various disparate and frequently incomparable data sources into different forms of viewing platforms [21]. Nevertheless, its analytical capability is indisputable, with several such dashboards infused with geographic information system (GIS) functionality and other forms of basic data visualization [30]. Similarly, ICT-based solutions are being used to foster interactions between service providers and customers.

#### 4.1.5. Evidence-Based Planning Decisions

A current problem for city governments is gaining public support for the necessary moves toward sustainability in the future. The role of BDA, in general, for long-term planning decisions may appear less evident when compared to that of automated real-time management and coordination capabilities [79]. Nonetheless, the ability to collect and interpret massive amounts of data from many sources can provide inputs for future planning [80]. Dashboards can monitor and illustrate the patterns related to various urban metrics. Evidence-based planning aims to address these challenges by empowering and providing local people with the evidence necessary to develop an optimistic target for the future.

### *4.2. Linkages between Urban Management and Sustainability*

In urban development, data-driven smart strategies make a significant contribution to developing and promoting environmental sustainability [81]. Findings suggest that the key data-driven smart technologies are applicable to boosting and advancing environmental sustainability [18]. The key dimensions of sustainability, namely, social, economic, and environmental, directly affect the drivers of urban management. This study reveals several indicators under these three main dimensions. Whereas the social dimension covers social justice, the quality of urban life, and people's participation, the economic dimension covers urban citizens' average income, affordability, access to food and nutrition, and finance. Similarly, the environmental dimension addresses urban green space, sustainable transportation, waste management, and energy management.

A popular and contemporary aim of many urban planning policies in different countries is sustainable development. Urban development's need for technological excellence is significant, particularly for sustainable urban development; thus, no one can ignore technology's value for sustainable urban development [82]. Numerous opinions can be found for what a sustainable urban area should be or should look like; consequently, different styles of conceptualization can also be found. In general, sustainable urban management (SUM) can be understood as a set of strategies for operationalizing sustainable growth or as the practical application of knowledge regarding sustainability and related technologies [72]. Therefore, balance as an interconnected mechanism must be achieved between four measurements: the environmental dimension, economic dimension, social dimension, and SUM. Some key sub-dimensions under the four pillars also need to be considered as aspects of sustainable urban development. These include the smart environment, smart energy, smart waste management, smart traffic, smart transport, smart planning, smart healthcare, smart safety, smart infrastructure, and people's participation (Figure 3).

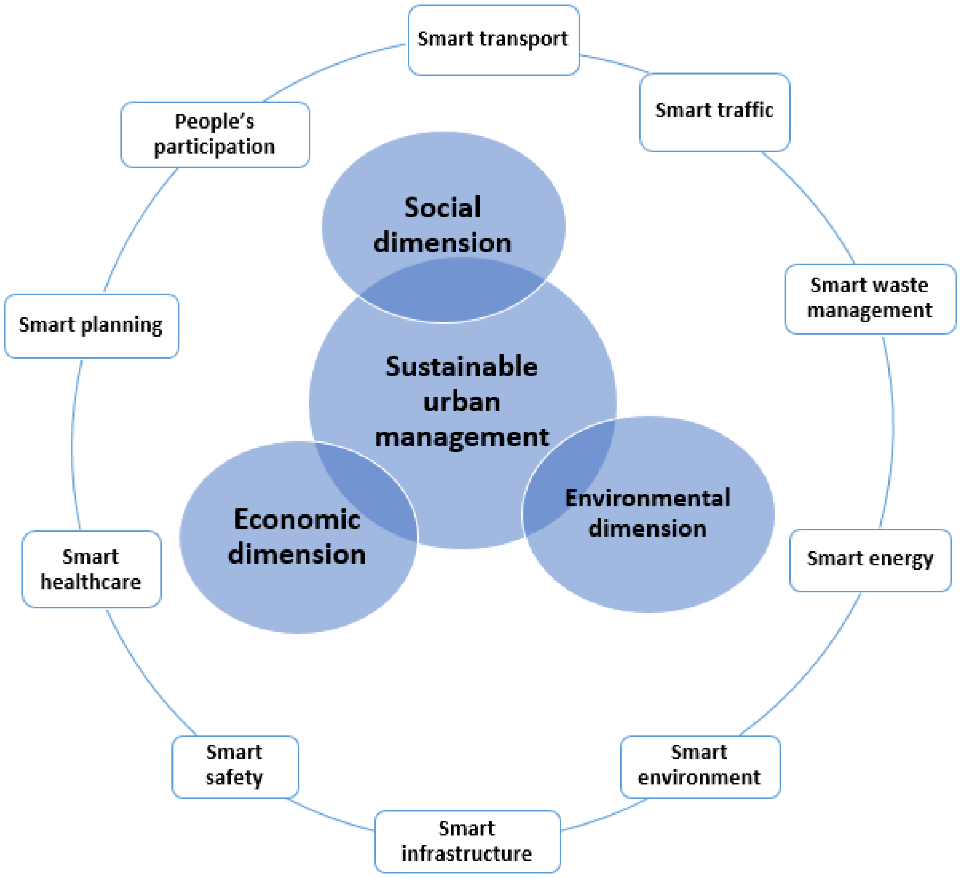


**Figure 3.** Framework for sustainable urban development.

### *4.3. Application of Big Data Analytics (BDA) for Smart Urban Governance*

Big data analytics (BDA) provide public agencies with tremendous opportunities to efficiently analyze data from many citizens, which eventually helps those agencies to make suitable decisions [83]. Therefore, BDA are useful for urban management organizations and actors, as well as other related stakeholders [11]. The government has a significant duty to produce and maintain information and to disseminate it to the public. Its role is vital to the development and management of knowledge that can be handled through the study of big data [81]. The primary and most common functions of big data are summarized in four main activity pillars, namely, data collection, combination, analysis, and use [65]. Other essential activities concerning big data include the following: annotation, recording, acquisition, selection of intelligence, extraction, integration, analysis, visualization, deployment, and evaluation, with these being the fundamental activities documented in several sources in the literature [8,84].

### *4.4. Big Data Analytics (BDA) for Sustainable Urban Management (SUM)*

Numerous topical studies focus primarily on data-driven smart urban management [60,85–87] without delving into how this method might improve and progress sustainable urbanism under the umbrella of what has been dubbed the "sustainable city" [88]. This would be data-driven and would form a leading urbanism paradigm. Furthermore, research on BDA in smart cities is frequently focused on economic growth [28,89]; quality of life [90,91]; and governance [92], while ignoring the most pressing issues and complicated challenges associated with sustainability. This research gap is particularly pronounced when it comes to the unexploited potential of BDA and their creative uses for promoting urban sustainability. Indeed, many emerging smart solutions are incompatible with sustainability objectives. Big data is a key tool for managing the city to ensure urban management actors' efficiency, quick service delivery, effective monitoring and accountability, and improved communication efficiency. By analyzing big data, cities' administrators and policymakers can more easily make appropriate decisions.

## 5. Conclusions

The world today is experiencing considerable change and facing many challenges. Urban management teams worldwide are facing challenges due to the changing socio-ecological context of cities. No alternative is available, other than to use a tool like BDA with its potential for efficient urban management by reducing urban administrative vulnerability and enhancing urban resilience and sustainability. Similarly, technological support is necessary to handle significant challenges arising from the rapidly increasing urban population to manage cities and provide a comfortable urban life. This study has sought to examine the suitability of big data for sustainable urban management. This paper contends that urban management is a united function of public and private entities working together to tackle significant urban life challenges and to build more competitive, habitable, and sustainable urban development. Urban sustainability can be accomplished by strategic planning under three major aspects, namely, social, economic, and environmental dimensions, to ensure the smooth operation of urban affairs. Big data technology can provide smart mobility, smart traffic, smart waste management, smart electricity, smart environment, smart infrastructure, smart security, smart healthcare, smart planning, and people's engagement in daily urban affairs to ensure a better urban life. Implementing big data for urban management can provide timely, error-free, adequate, and cost-effective services to the urban citizen and ensure urban sustainability.

## 6. Limitations and Future Research Directions

The lack of primary data as proof of BDA's function in assuring urban management and sustainability is a flaw in the study. Besides, the results have been drawn based on the selected documents by PRISMA. Future research might overcome this gap by using primary data to demonstrate the key roles of BDA in urban planning. As an innovative paradigm, big data-driven smart urbanism is incredibly diverse, encompassing a range of research questions and integrating a variety of theoretical and disciplinary viewpoints. As a result, several avenues present themselves for future research, and here we highlight several issues that are particularly pertinent to this study. The study's findings indicate that future research should focus on leveraging emerging inventions in BDA and the latest technologies to enhance and advance the crucial practices of sustainable urban management (SUM). Therefore, more effective strategies are necessary to address complex urban challenges and the weak link between smart urban management and urban sustainability. Additionally, the many difficulties connected with current urban management and sustainability approaches must be addressed, specifically their faults, inadequacies, limitations, and misunderstandings about sustainability. This refers to the necessity for cities to embrace or significantly improve their contribution to sustainable development goals as part of their conception and operationalization of future routes toward attaining sustainable smart cities. Moreover, an appealing topic of research is the examination of various avenues for developing new methods for sustainable smart urban management. Indeed, this leading paradigm of urban governance combines the smart city's capabilities to ensure efficient urban management.

**Supplementary Materials:** The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/land11050680/s1, Table S1: Big Data-Driven Urban Management: Way to Urban Sustainability (Reference [93] is cited in the Supplementary Materials).

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