International Journal of Engineering & Technology, 6 (3) (2017) 83-92

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

The characteristics of the green internet of things and big data in building safer, smarter, and sustainable cities

Mowafaq Salem Alzboon [1] *, Saleh Ali Alomari [1], Mohammad Subhi Al-Batah [1], Mustafa Banikhalaf [2]

[1] Faculty of Science and Information Technology, Jadara University, Irbid, Jordan
[2] Faculty of Information Technology and Computer Science, Yarmouk University, Irbid, Jordan
**Corresponding author E-mail: malzboon@jadara.edu.jo*

Abstract

The world's population development and high needs for limited goods are the results of proposing the need for further effective use of various resources and materials. Since current improvements in Information and Communication Technology (ICT) have entirely transformed massive regions, their use brings a negative effect on the environment and human health. Accordingly, the community's direction is aimed at bringing a greener future where using non-renewable and raw resources and materials are minimized when energy consumption and pollution are minimized. As ICT represents a mechanism for pointing out for many different environmental issues, Green Internet of Things (G-IoT) is considered to represent an extremely important role for generating a sustainable and green place for living. Big data analysis is considered significant in performing valuable visions from large and many different G-IoT created data. The gained knowledge provides seamless forecasting, decision-making and other actions related to smart city services. Consequently, it continuously performs various developments for G-IoT technologies. Therefore, despite that the image of sustainable and smart cities is being real, G-IoT methods and visions are produced from Big data analysis that makes cities appear importantly safer, smarter and further maintainable. Accordingly, this paper attempts at summarizing the role of new technological developments and attainments of big data within the procedure of building up cities where the life's quality is improved with minimized pollution and further effective uses of goods. It is inferred and realized that big data and G-IoT are effectively and symbiotically functioning towards completing a sustainable and smart vision of a final city.

Keywords: *Big Data; Green IoT; Smart City; Sustainable City.*

1. Introduction

Based on the predictions of the United Nations (UN) [1], the world population will approximately approach to 10 billion by 2050 in comparison to the current 7.5 billion populations. Such an important human population growth is seen as the result of developed living circumstances and attainments through contemporary medicine. At the present time, there exist 21 megacities (10+ million citizens), while about 1 million citizens transfer to cities daily [2]. It is expected that approximately 70% of the world population will be residing in urban cities by 2050 as a concern of high levels of urbanization and hastening migration [3]. This reality can increment several needs on infrastructure and a resource which refers to the importance of creating cities and the world with a safer, smarter and further sustainable environment (see Fig. 1). The smart and green city is considered to be a vision that is currently represented as real (see Fig. 2) [4]. Considerable developments in Information and Communication Technology (ICT) support the developed quality of life, minimize the consuming energetic and limited goods and minimize risky pollutions and emissions. Since its emergence, Internet of Things (IoT) relies on billions of different embedded sensors and intelligent things, which allows connecting to any user everywhere and at anytime performs efficiently in revolutionising extremely large sectors, such as waste management, education, tourism, industry, agriculture, forestry and aquaculture, healthcare, transport, etc.).

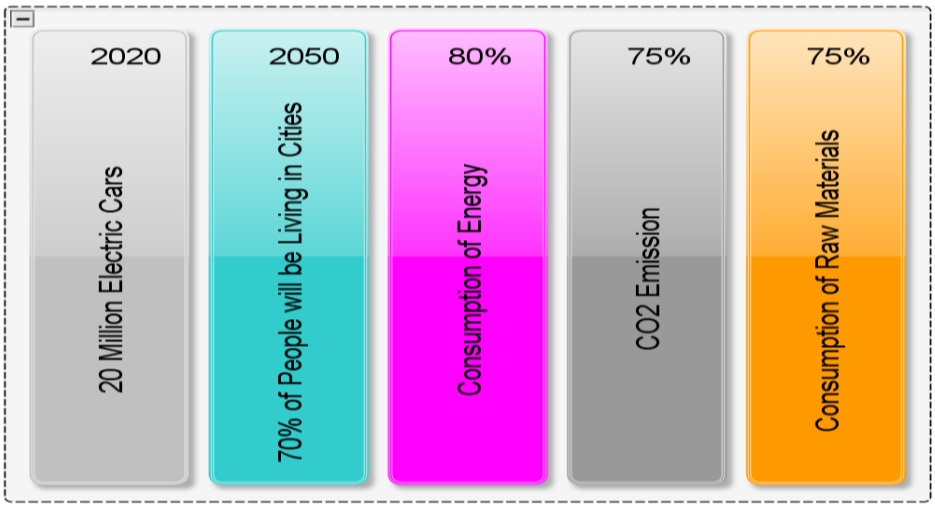

Fig. 1: The Increased Relevance of Cities.

Hence, causing to obtain a greener, smarter and more effective and practical world. Although there exist different remarkable advantages for the ICT and IoT, raising the number of intelligent devices that are being daily considered through newly produced technology methods provides a high-level energy and resource consumption and related e-waste and generating hazardous emissions. Moving through to a greener future where energy and restricted resources and materials are more resourcefully being utilized with reduced pollutions, is aimed at making greener and smarter place for living. Green ICTs, mainly, Green Internet of Things (G-IoT) has performed efficiently in realizing sustainable and smart cities.

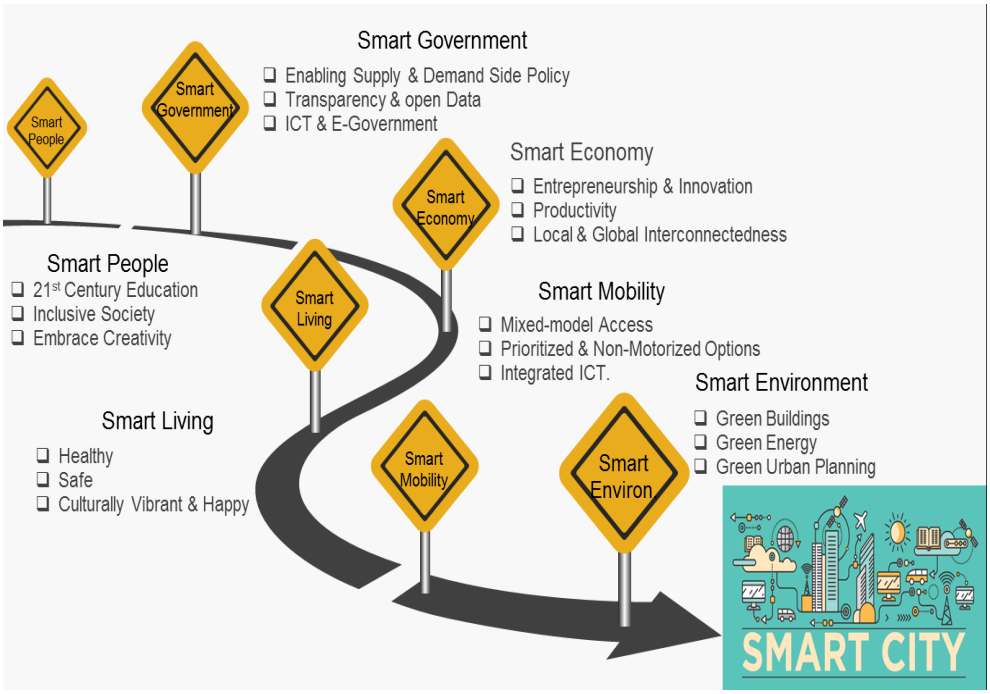

Fig. 2: The Smart City.

The continuous increase of utilized smart devices/things, which creates an enormous quantity of data where this means that the G-IoT is successful according to the big data. Additionally, Big data are featured by speed, diversity, and accuracy. Nonetheless, the gathered data itself is inadequate, and hence, analytics of big data proceed in. Implementing big data analytics allows performing advantageous visions such that suitable decision is performed and tasks are conducted. Hence, big data analytics performs importantly in order to comprehend an enormous quantity of information and helps in life's ever-changing developments by making cities become smarter, greener and safer. On the contrary, the analysis of an enormous quantity of data assists in continually developing the G-IoT based on current needs. Obviously, big data and G-IoT performs more effectively and bring incessant development of living environmental circumstances.

The paper attempts at assisting to comprehend the symbiotic relationship between Big data and G-IoT within the analysis related to their actions and performances in generating a smart and sustainable city by minimizing pollutions, energy needs and effective use of many different resources. Accordingly, this paper is organized as follows. Section 2 illustrates the basic aspects of the G-IoT along with its performance in realizing a smart and sustainable city. Established on the G-IoT generated data, Section 3 analyses particular different methods for coping with the voluminous nature of variety and within real-time created data. The analytics of big data along with its importance in improving living circumstances are indicated through this subsection. Finally, Section 4 provides conclusions pertaining to the study.

2. Green internet of things (G-IoT) and its role in creating smart and sustainable cities

Creating a sustainable region for living needs to involve the entire companies, governments, and stakeholders including individuals that are entirely based on the influence of the individuals' daily performances over a human's health and involved environment. Accordingly, problems are efficiently reduced where such issues comprise weather variations, the reduction of natural resources and vanishing biodiversity. The development of the G-IoT vision causes struggles in developing life's quality within sustainability and environmental safety by utilizing technology improvements (see Fig. 3) [5].

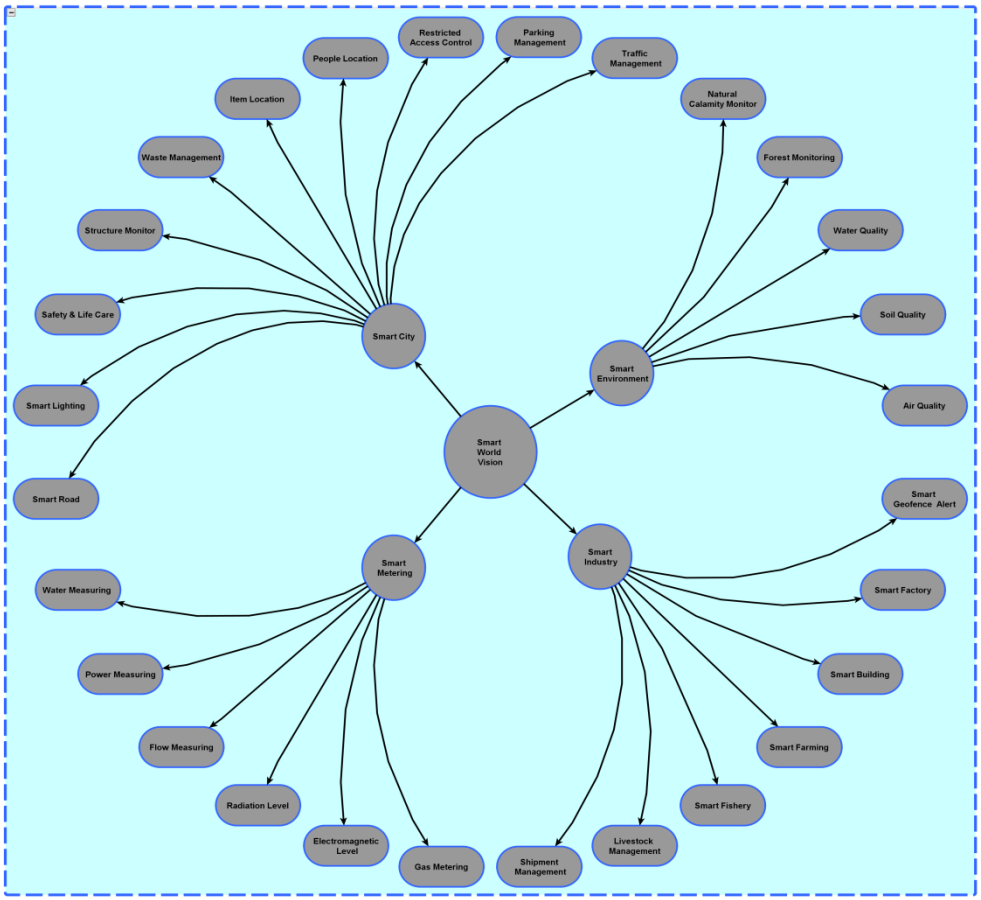

Fig. 3: The Vision of the G-IoT Smart World [5].

Generating a system of systems by linking billions of infrastructures, vehicles, and devices anywhere within a city, allows stakeholders to minimize water consumption, energy, and carbon emission by increasing safety effectivity including human well-being [2].
The G-IoT comprises two concepts [6]:

a) Formulates and produces green communications protocols, networking architectures and computing devices with improved power consumption and maximized bandwidth uses.
b) The use and removal of green technologies and devices for reducing pollutions and carbon emissions improve the energy's effectivity.

The G-IoT architecture comprises the following items of buildings [6] Sensing nodes, Fog/Edge nodes representing local embedded processing nodes, Processing cloud-based embedded nodes, Software to automate functions and allowing current classes of services and Security that is applied through the signal path [7]. Consequently, realizing the G-IoT vision takes the inclusion related to the top green ICTs into account. For instance, biometrics, Cognitive Radio Networks (CRN), Radio-Frequency Identification (RFID), nanotechnologies, Wireless Sensor Networks (WSN), Machine-to-Machine (M2M) communications, cellular networks, big data analytics and energy harvesting devices, Cloud/Fog/Edge computing and communications at the present time [8], [9] (see Fig. 4).

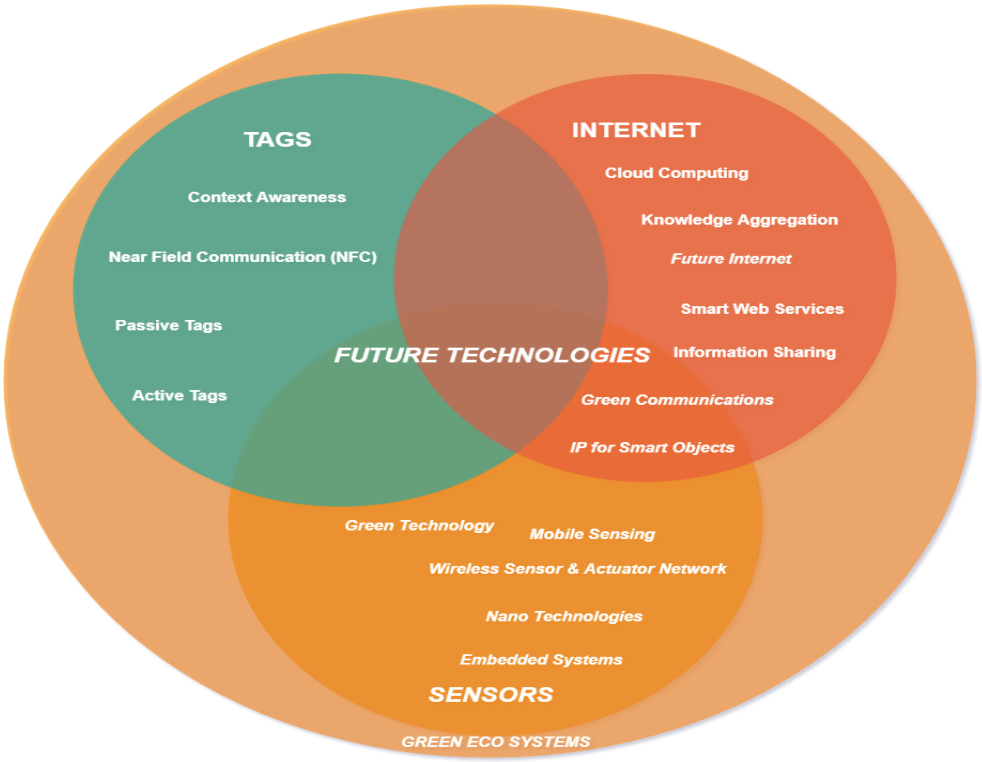

Fig. 4: The Enablers of the G-IoT [6].

The RFID and WSN are two corresponding types of machinery, which allow for identifying each item within the IoT according to their cooperation, collaboration, and connection. Therefore, the IoT is transformed into the G-IoT when just important attainments are achieved within the procedure of producing the RFID and WSN greener. The WSN represents a set of spatially disseminated sensing devices that are capable of monitoring and recording various kinds of conditions. Additionally, the WSN is considered an indispensable resource for determining the vision of the IoT.

Novel materials and designs that are applied for producing many different WSN building items and developing the energy effectiveness pertaining to the WSN devices when networking protocols and signal processing are realized let the WSN be greener compared to how it was previously. Energy-efficient, price-effective, reliable and secure WSNs are extremely significant for realizing the G-IoT. The RFID, as a reduced priced and seamless technology, is applied through a number of implementations in order to determine and trace individuals or items within real-time. RFID represents one of the most rapidly developing wireless technologies at the present days [10]. Based on its characteristics and capabilities, it is considered to be more than needed within the IoT. Nonetheless, like any existing ICT, RFID possess a negative impact on the environment. In order to minimize or remove the harmful impacts of the RFID over the environment, several changeable procedures, new objects and methods for producing different biodegradable RFID systems are continuously being identified [11]. The research community that attracts interest and motivates important investments concentrates on the novel's investigation, energy-efficient and reduced costs tags design based on the use of current objects, such as the textile fabric, plastics, and conductive adhesive, and including such methods as passive wireless RFID sensors and chipless RFID tags [10].

The attainment of the G-IoT vision needs further energy and price-efficient, consistent and protected M2M communications including information networking architectures [12]. M2M communications are considered to represent communication through multiple devices/things excluding human's intervention. Additionally, they represent a basic part of IoT [13].

Since the major aim of green communication technology is to reduce energy consumption and CO2 transmission within networking and communication devices, the massive quantity of responsiveness and substantial research is based on the networking games, green wireless communication, relay determination approaches related to green communication, developing communicative architectures, energy efficient packet forwarding and energy efficient routing [14], [15]. Since the G-IoT is generated through the green disposal, green communication, green processing, green utilization, and green design, the subsequent functions are needed to be conducted for realizing the perspective of the G-IoT [13], [15]–[18]:

a) Applying an eco-friendly formulation and implementing bio-products within productive procedures related to the contents of the G-IoT.
b) Reducing the energy consumption and effective prices by formulating and manufacturing the formulation and by generating contents related to the energy-efficient G-IoT.
c) Closing the G-IoT tools once these tools are available.
d) Applying sleep scheduling algorithms.
e) Increasing the effectivity pertaining to data center cooling including power supply.

Applying different renewable green power resources as biogas sources, wind, solar, oxygen, geothermal, and water. Only transmitting data once it is demanded; Reducing the length related to the data path including the length related to the wireless data path; Modifying the way of functioning multiple communications, such as compressive sensing and data fusion. Applying improved communication mechanisms, such as cognitive radio utilization and MIMO (Multiple-Input-Multiple-Output). The presence of security problems within the application level, G-IoT architecture, communication network and sensing infrastructure. The findings related to the achieved previous functions comprise utilization, improvement, manufacturing, design, and removal of related G-IoT contents within an economically and environmentally liable manner. Consequently, the G-IoT that is seen more energy-efficient in comparison with the IoT minimizes the quantity of greenhouse gas emissions and waste, which have unimportant or no influence over the environment including human health. The examples of the way G-IoT solutions perform realizing a smart, green and safe city are briefly outlined:

a) Having a smart, robust and green sustainable world, a vital concern is represented by the energy sector. Conventional possibilities for electric creation relies on consuming fossil fuel, leading to a raised weather change, global warming and carbon emissions [19]–[21]. Accordingly, it is important to enable the energy sector to be more environmentally sustainable and friendly. The solutions pertaining to advanced technology and G-IoT, are in particular capable of realizing further effective dissemination and usage of energy [2], [22], leading to a developed balance between supply and energy needs. Such solutions are accomplished based on the use of an integrated energy network including a massive network related to sensors, actuators, smart meters and smart appliances that could automatically remain to track the flows of the energy and modifies it to be modified [23]. This paradigm is common for the concept 'Smart Grid (SG)'. Since the incessant development of smart devices applied through the SG causes a raised consumption of energy and emissions of carbon, it is obligatory to apply green power resources, green computing technologies and green communication within the SG that causes to create a new perspective, which is the Green SG (G-SG). In fact, the G-SG represents a self-healing and autonomous system, increased reliability, increased quality and secure usage of resources based on ideal approaches. It is price-effective and maintains environmental protection [24]. G-SG enables creating a decentralized and variant energy generation, dissemination and storage, and simplifies the combination of disseminated and renewable energy resources, such as geothermal, wave, hydro, solar and wind [7], [25]. As it is expected that the G-IoT will importantly contribute in accomplishing the European Union's objectives, not till before 2020 (minimized emissions of carbon by 20%, savings of energy consumption by 20% and raising the dissemination of renewable sources to 20%) [26], the SG's future generation shall be entirely automated and G-IoT-based undoubtedly.

b) Smart water management, which a different important building block related to smart cities, comprises a combined to ICT systems, solutions, and products within regions of managed water flow, pressure and dissemination [27]. The G-IoT's perspective is able to deliver important water savings for building sectors, and hence, develops a managed sustainable water. Based on the assistance of smart metering devices, remote monitoring and real-time related to water consumption and diagnosing issues, the G-IoT can optimize the entire concepts that are in relation to the water management system.

c) The basis of G-IoT solutions within smart buildings represents the combination of the entire devices (e.g. electricity smart meters, home automation gateway, tracking the consumption of water and gas, lighting, HVAC (Heating, Ventilating and Air Conditioning), home smart appliances, video and audio, etc.) including the linking between smart building and people, other different buildings, environment, smart grids and technology [22]. Additionally, the G-IoT efficiently develops the entire building of life cycle, from urban planning and formulation, building and processing, to maintaining and eliminating. Consequently, realizing green buildings to form sustainable structures including an importantly raised energy and water effectivity and minimizing carbon footprint through buildings is approaching the reality in efficient manners. In [28], it is realised that Leadership in Energy and Environmental Design (LEED) certifications, green buildings and net-zero energy buildings (buildings which minimize the usage of non-renewable energy based on providing sufficient renewable energy for satisfying its particular needs of an energy consumption [29]) is expected to possibly get highly become increasingly pervasive. The G-IoT can importantly contribute to it based on producing smarter buildings and more effective according to the use of resources and energy, and by securing them for further sustainable, safer and user-friendly environment [8], [30]–[34].

d) Since more individuals reside within the city, the further waste remains produced daily resulting in an enormous challenge when realizing green and smart cities. It is expected that the volume of the global waste will be 50% raised on the coming few years [35], [36] and shall approach 2.3 billion tons within the end of 2025 [37]. Irrespective of the waste type (e.g. recyclable, organic, chemicals, liquids, hazardous, solid and toxic) and their resource (e.g. commercial and residential buildings, transport and streets, hospitals, construction, industry, houses,). The smart waste management represents a prerequisite for the fruition pertaining to a sustainable, green and smart city perspective. Accordingly, an increased concern in efficiently understanding waste management exists. Various industries around the globe produce IoT-based systems for further efficient waste management, such as Sutera, Bigbelly, Compology, Enevo, etc.) [38]. The solution of waste management relies on the G-IoT stands that are related to the current practices or technologies of an appliance when eliminating pollutions and waste, and gathering and recycling or reusing waste, by transforming it into valued resources. Linked waste management within the city level aims at importantly delivering price-savings and reduced CO2 emissions [2], [22].

By taking the speed of urbanization including cities dimensions into account, urban surveillance can represent a substantial part of the vision of a smart city. Effective surveillance of a smart city is a decisive interest through extremely large dynamic and critical dynamic data-driven functions [39]. The transport sector represents an extremely important type of a smart city as it requires a sufficient step of surveillance and monitoring. Additionally, knowing that the transport sector controls around 25% of global CO2 emissions and indicates the importance of producing such a sector that is greener and smarter as highly as it could be. G-IoT can importantly attempt at reducing pollutions, associated emissions, and energy consumption within the transport sector. By minimizing trips and being apart from it, proceeding through a further environmentally effective transport modes and developing a fuel and vehicle technology comprise three major interrelated essentials, which should be accomplished for realising a sustainable and smart transport [13], [15], [32], [34], [40]. Realizing the vision related to the Internet of Vehicle (IoV) in which many different kinds of vehicles remain linked together, more effective services are provided with developed effectiveness and protection. For example, linked emergency vehicles allow responders to approach emergency cases, views, and incidents more rapidly in order to provide assistance for patients as possible as it could be. Ride-sharing and car-sharing services assist to reduce time, traffic congestion, resources, and price savings and transport-related emissions. Linked streetlights allow remote modifications to light up, meantime, minimize energy consumption and related costs in order to make a city with its roads more protective. Additionally, video surveillance system attempts at protecting cities by tracking pedestrian and vehicle traffic and assisting crime determination [32]. Consequently, the G-IoT enhanced tracking traffic jams, optimization related to goods' flow and route planning are considered examples for reducing the negative impact on transport systems within the environment and reducing reliance over energy and fossil fuels [41], [42].

The mentioned instances are seen comprehensive and demonstrating the potentials of the G-IoT for producing important developments in energy efficiency, cost-saving, reducing resource consumption and reducing negative influence over the environment. Hence, causing the view of the sustainable, protective and smart city to completion. Smart services, smart infrastructure, and smart buildings demonstrate that the G-IoT is considered a suitable tool for firming up environmental and economic sustainability.

3. Big data contribution in making cities smarter and sustainable

Knowing that the G-IoT and IoT gather and use data, their achievement relies on big data. Accordingly, it is important to comprehend the connection between big data and G-IoT through their progress in order to effectively conduct analysis, obtain many different and perceptive outcomes and perform sufficient and effective performances. The ten efficient instances related to Big data and IoT symbiosis are given in [43]. The entire examples represent the robustness of big data and G-IoT analytical connections. Nonetheless, enormous volumes and rapid created data of many different and frequent devices, such as cameras, computers, RFID tags, smartphones, GPS, sensors, and many others, should be managed and operated to gain definite knowledge and conduct suitable actions. Accordingly, efficient analysis and usage of a massive quantity of many different data types (structured and unstructured), which is delivered within a real-time velocity and represents an indeterminate origin (veracity) are considered obligatory within the procedure of gaining valuable visions. Managing such created information within the vision of a smart city is difficult when applying conventional SQL-queried Relational Database Management Systems (RDBMSs). Using the Non-relational databases (NoSQL databases) along with the Hadoop distributed data processing system allows to accomplish significant visions that may be derived from a gathered data [44]–[47].
The cloud computing service and G-IoT allow storing, process and mining data based on an effective way. Cloud computing manages a large volume of urban dynamic data in an effective way by allowing to analyze robust computing tools [39]. Additionally, transferring particular application services or procedures through to the end of the network causes a minimized quantity of data, which should be handled, analyzed and maintained. This method indicates to Fog computing [39], [48] and importantly develops data storage, handling, and analysis within the implementations, which need processing and real-time data storage (e.g. smart city). Combining the G-IoT and the entire improved services of ICTs makes collecting the data of a smart city simple. it's delivering and analysis in order to perform adequate actions for the city's service improvements, urban planning, and governance [9], [19], [34]. There exist many different soft computing approaches, which are used to obtain significant visions derived from the gathered data and to produce smart decisions (Fig. 5) [49]. Common machine learning and data mining techniques as classification, outlier detection, novel algorithms, clustering, visualization, neural networks, frequent pattern mining, and fuzzy logic techniques are used based on the issue domain, dataset compatibility and required result [50], [51].

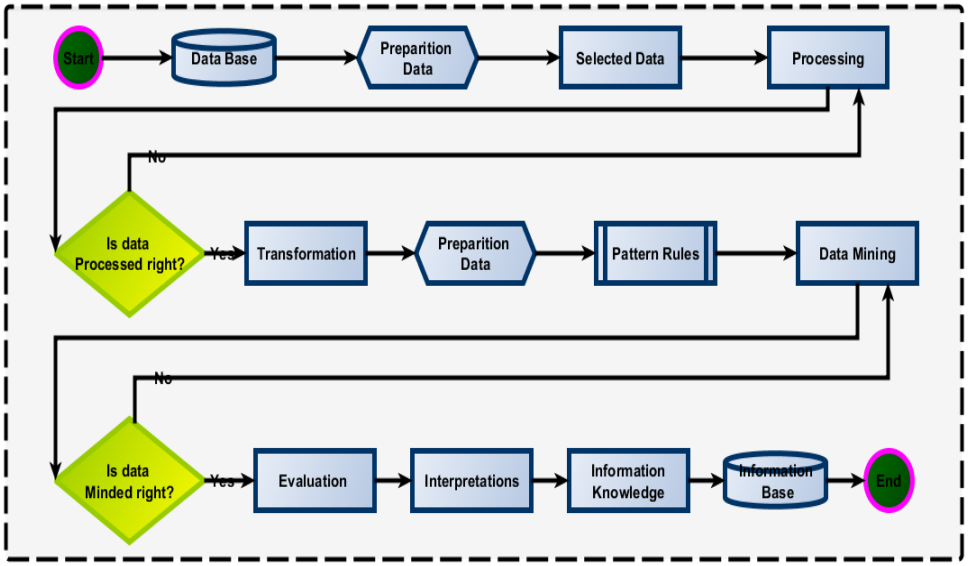

Fig. 5: Knowledge Extraction.

The performance of big data analytics and G-IoT when realizing a green and smart vision of a city and developing various services of smart city services is briefly highlighted: The technology process facilitates the use of smart meters, which allow measuring many different online resources consumption (e.g. water, gas, heat and electric). Consequently, smart meters create data that is significant for efficient resource management. Additionally, big data analytics that is being used for data that is collected from smart meters, sensors and smart devices allow conducting consumption estimation, outages decreases, and tracking possessions. G-IoT contents including the contents of Cloud/Fog/Edge-based automated management system can effectively enhance efficiency for water and energy consumption. Based on visualizations and Big data analytics, sufficient estimations and averting activities including many different smart decisions are produced through appropriate resource management [52]. Hence, data analysis is created and applied by the entire electrical devices. Further smart devices that are utilized within the insight of green and smart building allow accomplishing more effective visions based on the use of energy and many different resources. Additionally, it provides an improved observance, management and modified activities [53]. For instance, it is anticipated that smart grids within the future shall possibly comprise micro-power system networks that are connected together through the cloud and shall be able to track, process or disconnect each other and perform efficiently according to the gathered data. This connection will possibly include smart metering devices [54], [55]. Furthermore, by applying inventive building automation systems and building management systems, energy consumption of the building sector is minimized by 30-80% [29].

- The waste management system that relies on the G-IoT includes the power for collecting data from several information systems and sensors, which consist of information regarding the traffic congestion, garbage truck location, and container filling level. The gathered data remains to be conveyed through to the cloud making waste management industries be involved un-optimized, predictive and analytical tasks [56]. For example, optimizing a container collection is performed according to the sensor data, which comprises information regarding the waste level. The container acknowledges the final aggregation or waste level according to the data, which remains marked for aggregation. Garbage truck can just aggregate complete or delayed containers, meantime, causing to optimize the routes related to a garbage truck. Consequently, the G-IoT can effectively perform for further enhanced, cost-

efficient and sustainable waste management transporting advantages to indirect and direct parties that are included within trash disposal.

- Smart city surveillance systems are important for ensuring public security and fighting crime. Such systems ease identifying any violent act and involved individuals and allow tracing individuals and items. Additionally, these systems provide an alarming system once any case occurs [34]. Further, using intelligent infrastructures, location-based applications, cameras, and smart sensors can efficiently develop transport sector by making it sustainable and secure. Optimization and traffic control are efficiently improved based on the assistance of the G-IoT. Linking control systems, lights, roads, and vehicles all together generate large quantities of data at higher velocities [57]. Analyzing and collecting real-time information over traffic situations put parking, driving, and traffic more effective [58]. For instance, the solutions related to the G-IoT, which rely on gathered and managed data identify the most effective ideal driving velocity and direction in order to prevent congestion or to assist drivers in being the nearest existing parking place within a busy region. Citizens who are regularly using their mobile devices and smartphones could frequently get actual-time information on public transportation along with its existence. Moreover, street lights are being modified based on individuals' existence within a specific region and by ensuring safety and decreased energy consumption simultaneously [44], [32].

The above list only highlights some advantages pertaining to the G-IoT and big data analytics by providing a realization of a smart city insight. Accordingly, the G-IoT big data is unseen as a separate entity but is integrally connected to each other. Consequently, valuable visions are possibly derived and are seen as smart through on-time decisions for developing life's quality based on improved services and smart city infrastructure.

4. The assessment of city's sustainability

The issues of having greener and smarter cities comprise security, safety, communication, sustainability, efficiency and cost [22]. To solve the issues of enlarged urbanization, such as waste and emissions expansion, deficiency of services and resources' overexploitation, significant objectives of city's sustainability (e.g. economic, social, and environmental sustainability) should be fulfilled [59]. The economic sustainability of a city is based on providing more effective and incorporated infrastructures and services over current financial approaches. Thus, an enhanced life's quality can perform effectively in the attractiveness of a smart city for capital, business, and people. Additionally, an inventive infrastructural and technological integration helps to reduce the negative effect of a smart city's environment causing environmental sustainability [60]. Smart cities' sustainability can be possibly measured by significantly considering environmental possessions' quality, the effective use of many different resources, risks of climate change and highest social and economic social co-benefits [61]. The measurement comprises the evaluation of about 30 qualitative and quantitative indicators based on the subsequent classifications, which comprise [62] [63]: environmental governance, land use, water and sanitation, energy, waste management, air quality, buildings, transport, and CO2 emissions (see Fig. 6).

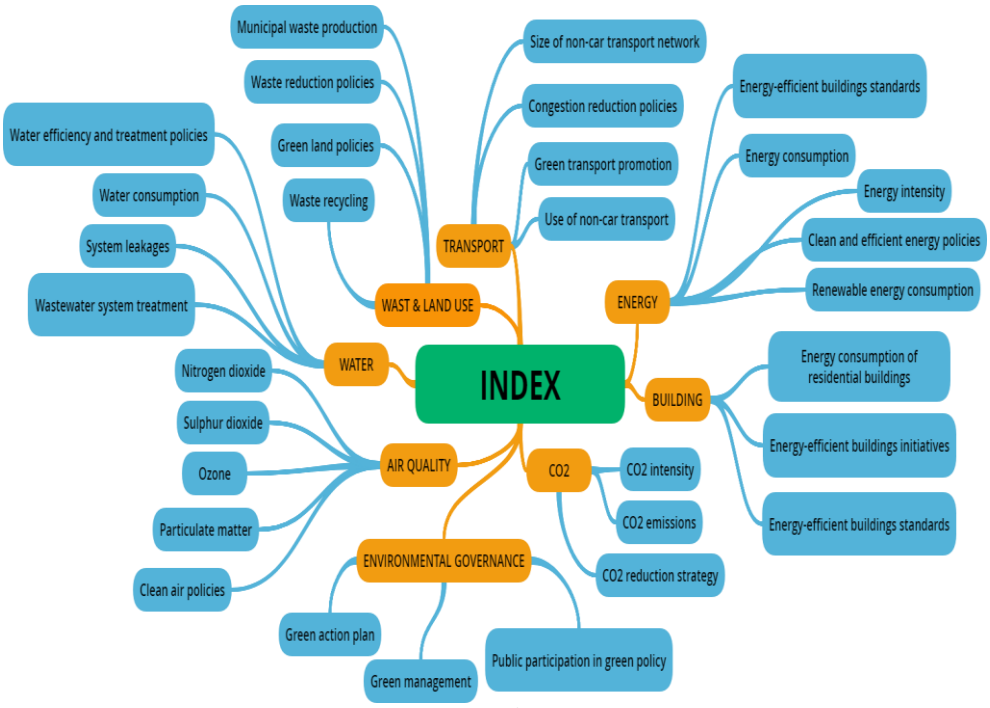

Fig. 6: Indicators of A Green City.

The obtained outcomes related to the relative analysis are highlighted within many different studies in [61]. Based on [53], the entire sustainable cities index that is ranked in 2016 are illustrated (see Fig. 7).

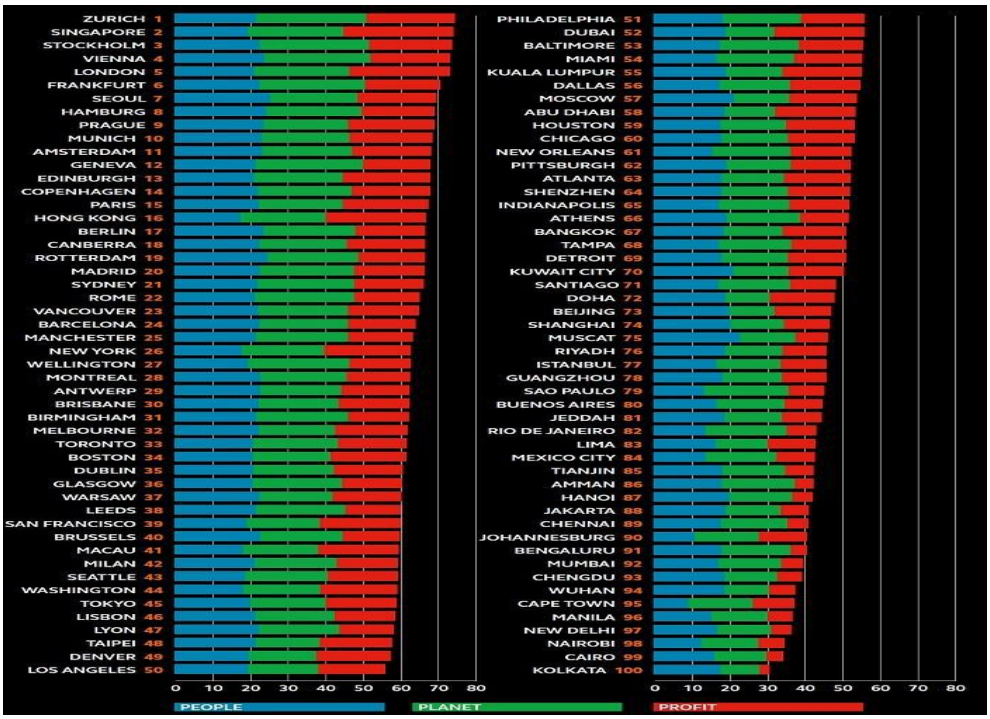

Fig. 7: The Entire Rankings of the Sustainability City Index [53].

Since the evaluation of cities' sustainability including the revealing ranking is conducted by approximately applying 30 various indicators, it is obvious that a large quantity of various created data at real-time is operated. Thus, the introduced ranking relies on the obtained knowledge by implementing big data analytics over the gathered data. As the obtained finding takes into account cities' care for citizens, profit (social, environmental, and economic sustainability), and the planet the G-IoT, regardless of how its promising nature, it delivers an increased possibility to importantly develop various services and implementations of smart cities. Hence, it is anticipated that the G-IoT's explosion and big data including their symbiosis will represent its power in developing life's quality when implementing smart, sustainable, safe and secure places to reside in.

5. Conclusion

In this section, you should present the conclusion of the paper. Conclusions must focus on the novelty and exceptional results you acquired. Allow sufficient space in the article for conclusions. Do not repeat the contents of the Introduction or the Abstract. Focus on the essential things in your article. Since the human's presence, the propensity of having a sustainable, good and safe place to reside has not been altered. Based on the technology developments, the insight of smart, green and safe living regions represents the reality. An increased number of citizens with their extenuation to urban regions mean that the raising consumption pertaining to limited goods and resources, including an expansion of hazardous and waste emissions. Since the advanced technology can importantly perform through to the completion of sustainable and smart city insight, it can possess a negative influence over the environment, and thus, over the human. To manage such challenging issues, it is significant to conduct definite activities that can possibly minimize the negative influence over the human and environment. Developing green technologies, particularly the G-IoT, are seen to represent a sufficient and appropriate solution. Formulating, creating, applying and elimination of devices and products based on a greenway (excluding a negative impact over a human's environment and health) allows for the G-IoT to represent a smart world's practical strength and future's advancements. The presence of the G-IoT services and devices when realizing a smart city insight causes to create a diversity and volume of produced data on a regular basis. To acquire valued visions from gathered data, it is significant to manage and analyze it. Acquiring knowledge regarding citizen's lives, feelings and work allows producing possible developments when functioning and handling smart cities. Consequently, the big data and G-IoT can just both perform effectively for efficiently developing life's quality leading to having a more efficient world, safer and further sustainable place to reside in.

References

[1] B. Long, "World Population Trends 1920–47," Int. Aff., vol. 27, no. 2, pp. 224–224, 2006. https://doi.org/10.2307/2606176.
[2] S. Wireless, "Make Cities Safer and More Efficient with Smart City Technology." [Online]. Available: https://www.sierrawireless.com/applications/smart-cities/.
[3] M. Kube, "What was new in smart city tech at MWC17?," IoT, 2017. [Online]. Available: https://blog.gemalto.com/iot/2017/03/03/new-smart-city-tech-mwc17/.
[4] M. Jadoul and J. Vermeulen, "Smart cities are built on smart networks," Techzine, 2014.
[5] A. Shoaee, "Green IoT Solutions .... Smart City - Smart Environment - Smart Industry - Smart Metering Solutions," 2016.
[6] K. Karimi, "The Role of Sensor Fusion in the Internet of Things (IoT)," IMID Dig., 2013.
[7] M. Maksimovic, "Greening the Future: Green Internet of Things (G-IoT) as a Key Technological Enabler of Sustainable Development," 2017, pp. 283–313. https://doi.org/10.1007/978-3-319-60435-0_12.
[8] N. T. Le, M. A. Hossain, A. Islam, D. Y. Kim, Y. J. Choi, and Y. M. Jang, "Survey of promising technologies for 5g networks," Mob. Inf. Syst., vol. 2016, 2016. https://doi.org/10.1155/2016/2676589.
[9] J. Dizdarevic, F. Carpio, A. Jukan, and X. Masip-Bruin, "Survey of Communication Protocols for Internet-of-Things and Related Challenges of Fog and Cloud Computing Integration," vol. 1, no. 1, pp. 1–27, 2018. https://doi.org/10.1145/3292674.

[10] Y. Duroc and D. Kaddour, "RFID potential impacts and future evolution for green projects," in Energy Procedia, 2012, vol. 18, pp. 91–98. https://doi.org/10.1016/j.egypro.2012.05.021.
[11] O. G., Y. L., R. A., A. F., T. M.M., and R. L., "Green Technologies and RFID: Present and Future," APPLIED COMPUTATIONAL ELECTRO-MAGNETICS SOCIETY JOURNAL, vol. 25. pp. 230–238, 2010.
[12] D. Christin, A. Reinhardt, P. S. Mogre, and R. Steinmetz, "Wireless Sensor Networks and the Internet of Things: Selected Challenges," 1, vol. 5970, pp. 31–33, 2009. https://doi.org/10.1007/978-3-642-11917-0_3.
[13] C. Zhu, V. C. M. Leung, L. Shu, and E. C. H. Ngai, "Green Internet of Things for Smart World," IEEE Access, vol. 3, pp. 2151–2162, 2015. https://doi.org/10.1109/ACCESS.2015.2497312.
[14] A. Bansal, M. K. Ahirwar, and P. K. Shukla, "A Survey on Classification Algorithms Used in Healthcare Environment of the Internet of Things," Int. J. Comput. Sci. Eng., vol. 6, no. 7, pp. 883–887, 2018. https://doi.org/10.26438/ijcse/v6i7.883887.
[15] M. A. M. Albreem, A. A. El-Saleh, M. Isa, W. Salah, M. Jusoh, M. M. Azizan, and A. Ali, "Green internet of things (IoT): An overview," in 2017 IEEE International Conference on Smart Instrumentation, Measurement and Applications, ICSIMA 2017, 2018, vol. 2017–Novem, no. March 2018, pp. 1–6. https://doi.org/10.1109/ICSIMA.2017.8312021.
[16] H. Wang, "Toward a Green Campus with the Internet of Things–the Application of Lab Management," World Congr. Eng. 2013, vol. III, no. 5, pp. 195–200, 2013.
[17] W. I. T. Matters, I. T. Runs, and O. N. Wind, "Going Green with the Internet of Things," Events.Windriver.Com.
[18] P. V. C. M. Leung, "Green Internet of Things for Smart Cities," 2015.
[19] F. Liang, X. He, W. G. Hatcher, C. Lu, J. Lin, X. Yang, and W. Yu, "A Survey on the Edge Computing for the Internet of Things," IEEE Access, vol. 6, no. c, pp. 6900–6919, 2017. https://doi.org/10.1109/ACCESS.2017.2778504.
[20] F. Jalali, S. Khodadustan, C. Gray, K. Hinton, and F. Suits, "Greening IoT with Fog: A Survey," Proc. - 2017 IEEE 1st Int. Conf. Edge Comput. EDGE 2017, pp. 25–31, 2017. https://doi.org/10.1109/IEEE.EDGE.2017.13.
[21] N. Abbas, Y. Zhang, A. Taherkordi, and T. Skeie, "Mobile Edge Computing: A Survey," IEEE Internet Things J., vol. 5, no. 1, pp. 450–465, 2018. https://doi.org/10.1109/JIOT.2017.2750180.
[22] S. P. Mohanty, U. Choppali, and E. Kougianos, "Everything you wanted to know about smart cities," IEEE Consum. Electron. Mag., vol. 5, no. 3, pp. 60–70, 2016. https://doi.org/10.1109/MCE.2016.2556879.
[23] M. Simonov, M. Mussetta, and A. Pirisi, Real time energy management in smart cities by Future Internet. 2010.
[24] R. E. Brown, "Impact of Smart Grid on Distribution System design," in IEEE Power and Energy Society 2008 General Meeting: Conversion and Delivery of Electrical Energy in the 21st Century, PES, 2008. https://doi.org/10.1109/PES.2008.4596843.
[25] P. Pazowski, "Green Computing: Latest practices and technologies for ICT sustainability," in Managing Intellectual Capital and Innovation for Sustainable and Inclusive Society; Management, Knowledge and Learning; Joint International Conference 2015, 2015, pp. 1853–1860.
[26] P. Stollenmayer, "How the Earth can benefit from Green ICT." [Online]. Available: https://www.eurescom.eu/news-and-events/eurescommessage/eurescom-message-archive/eurescom-messge-2-2011/how-the-earth-can-benefit-from-green-ict.html.
[27] R. Ahmed, "Smart Water Management in Korea," no. May, pp. 101–121, 2017. https://doi.org/10.1787/9789264281707-8-en.
[28] O. N. Wind, "Going Green with the Internet of Things - How Embedded and Connected Technologies Are Making a Positive Environmental Impact," Wind River Syst., 2016.
[29] N. Y. Jadhav, Green Energy and Technology Green and Smart Buildings Advanced Technology Options. 2016. https://doi.org/10.1007/978-981-10-1002-6.
[30] M. A., A. Mohammed, and M. Yamani, "A Brief Survey on 5G Wireless Mobile Network," Int. J. Adv. Comput. Sci. Appl., vol. 8, no. 11, pp. 52–59, 2017. https://doi.org/10.14569/IJACSA.2017.081107.
[31] R. For, A. G. Internet, and O. F. Things, "Reliability for a Green Internet of Things Reliability for a Green," no. January, pp. 45–50, 2019.
[32] M. Maksimovic, "The Role of Green Internet of Things (G-IoT) and Big Data in Making Cities Smarter, Safer and More Sustainable," Int. J. Comput. Digit. Syst., vol. 6, no. 4, pp. 175–184, 2017. https://doi.org/10.12785/IJCDS/060403.
[33] S. Lee, M. Bae, and H. Kim, "Future of IoT Networks: A Survey," Appl. Sci., vol. 7, no. 10, p. 1072, 2017. https://doi.org/10.3390/app7101072.
[34] S. H. Alsamhi, O. Ma, M. S. Ansari, and Q. Meng, "Greening Internet of Things for Smart Everythings with A Green-Environment Life: A Survey and Future Prospects," pp. 1–14, 2018.
[35] Telefonica, "Smart City Services: Smart Waste Management," 2017. [Online]. Available: https://iot.telefonica.com/multimedia-resources/smart-city-services-smart-waste-management.
[36] M. A., F. P., Z. A., A. T., and K. S., "Waste management as an IoT-enabled service in smart cities," Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol. 9247. pp. 104–115, 2015. https://doi.org/10.1007/978-3-319-23126-6_10.
[37] "Sodium Sulfur Batteries Market: Global Industry Analysis and Opportunity Assessment 2015-2025," 2017. [Online]. Available: https://www.futuremarketinsights.com/reports/smart-waste-management-market.
[38] "Refuse revolution: 4 companies transforming the trash bin."
[39] N. Chen, X. Ye, S. Song, Y. Chen, C.-T. Huang, and H. Ling, "Smart City Surveillance in Fog Computing," 2016, pp. 203–226. https://doi.org/10.1007/978-3-319-45145-9_9.
[40] J. S. Kumar, "Green Smart World (Internet of things)," Int. J. Eng. Sci. Invent., pp. 32–35, 2018.
[41] S. Li, L. Da Xu, and S. Zhao, "5G Internet of Things: A survey," Journal of Industrial Information Integration, vol. 10. pp. 1–9, 2018. https://doi.org/10.1016/j.jii.2018.01.005.
[42] D. E. Kouicem, A. Bouabdallah, and H. Lakhlef, "Internet of things security: A top-down survey," Comput. Networks, vol. 141, pp. 199–221, 2018. https://doi.org/10.1016/j.comnet.2018.03.012.
[43] C. Forrest, "Ten examples of IoT and big data working well together," zdnet.com, 2016. [Online]. Available: https://www.zdnet.com/article/ten-examples-of-iot-and-big-data-working-well-together/.
[44] Kaushik Pal, "How Big Data Helps Build Smart Cities," kdnuggets.com, 2015. [Online]. Available: https://www.kdnuggets.com/2015/10/big-data-smart-cities.html.
[45] Oracle, "Big Data Analytics (Advanced analytics in oracle database)," no. March, pp. 1–13, 2013.
[46] V. Hashem, Ibrahim Abaker Targio Chang, N. B. Anuar, K. Adewolea, I. Yaqooba, G. Abdullah, E. Ahmeda, and H. Chiromac, "The role of big data in smart city," Int. J. Inf. Manage., pp. 784–758, 2016. https://doi.org/10.1016/j.ijinfomgt.2016.05.002.
[47] C. McLellan, "The internet of things and big data: Unlocking the power," ZDNet, 2015.
[48] Cisco Systems, "Fog Computing and the Internet of Things: Extend the Cloud to Where the Things Are," white Pap. p. 6, 2015.
[49] C. Paper and E. Sarajevo, "Data acquisition and analysis in educational research based on Internet of Things," no. SEPTEMBER 2015, 2016.
[50] Keith D. Foote, "Techniques and Algorithms in Data Science for Big Data - DATAVERSITY," 2016-03-22. [Online]. Available: http://www.dataversity.net/techniques-and-algorithms-in-data-science-for-big-data/.
[51] A. Ali, J. Qadir, R. ur Rasool, A. Sathiaseelan, and A. Zwitter, "Big Data For Development: Applications and Techniques," 2016.
[52] ITU-T, "ICT as an Enabler for Smart Water Management," 2011. https://doi.org/10.1186/s41044-016-0002-4.
[53] ARCADIS, "Sustainable Cities Index 2016: Putting people at the heart of city sustainability," 2016.
[54] V. TAMILMARAN and K. DWARKADAS PRALHADAS, "Smart grid: an overview," Smart Grid Renew. Energy, vol. 2, pp. 305–311, 2011. https://doi.org/10.4236/sgre.2011.24035.
[55] F. Y. Okay and S. Ozdemir, "A fog computing based smart grid model," in 2016 International Symposium on Networks, Computers and Communications, ISNCC 2016, 2016. https://doi.org/10.1109/ISNCC.2016.7746062.

[56] S. Talari, M. Shafie-Khah, P. Siano, V. Loia, A. Tommasetti, and J. P. S. Catalão, "A review of smart cities based on the internet of things concept," Energies, vol. 10, no. 4. 2017. https://doi.org/10.3390/en10040421.
[57] V. K. Solanki, S. Katiyar, V. Bhashkarsemwal, P. Dewan, M. Venkatasen, and N. Dey, "Advanced Automated Module for Smart and Secure City," in Physics Procedia, 2016, vol. 78, pp. 367–374. https://doi.org/10.1016/j.procs.2016.02.076.
[58] S. P. Biswas, P. Roy, N. Patra, A. Mukherjee, and N. Dey, "Intelligent traffic monitoring system," Adv. Intell. Syst. Comput., vol. 380, pp. 535–545, 2016. https://doi.org/10.1007/978-81-322-2523-2_52.
[59] F. Bifulco, M. Tregua, C. C. Amitrano, and A. D'Auria, "ICT and sustainability in smart cities management," Int. J. Public Sect. Manag., vol. 29, no. 2, pp. 132–147, 2016. https://doi.org/10.1108/IJPSM-07-2015-0132.
[60] IEC, "Orchestrating Infrastructure for Sustainable SmartCities," 2014.
[61] OECD, "Green Cities Programme Methodology," 2016.
[62] A. Berg and S. Spencer, "What Is the Best Way to Measure Outcome?" 2013, pp. 633–638. https://doi.org/10.1201/b14113-57.
[63] Economist Intelligence Unit, "The Green City Index: A summary of the Green City Index research series," Economist Intelligence Unit, pp. 1–46, 2012.