I J C R M

International Journal of Contemporary Research In Multidisciplinary

Research Article

Development Of Environmentally Sound Smart Cities with Reduced Energy Consumption Using Green Internet of Things and Big Data

Ankur N. Shah *

Assistant Professor, P.P. Savani University, Kosamba, Gujarat, India

Corresponding Author: Ankur N. Shah*

DOI: https://doi.org/10.5281/zenodo.15283403

Abstract

The development of environmentally sustainable smart cities hinges on innovative advanced technologies that drastically reduce energy usage and enhance urban living. This paper delves into the transformative potential of combining Big Data analytics with the Green Internet of Things (IoT) to achieve these goals. The Green IoT comprises a network of interconnected devices and sensors that monitor and manage energy resources in real-time, facilitating the efficient use of electricity, water, and other essential utilities. By collecting vast amounts of data from these devices, big data analytics can provide actionable insights that can inform smart urban planning and resource management. This synergistic approach optimizes energy consumption, cuts waste, and minimizes the urban environmental carbon footprint. For example, smart grids adjust the energy distribution in response to real-time demand, and intelligent transportation systems can minimize traffic congestion and emissions. Moreover, the integration of these technologies supports the predictive maintenance of infrastructure, prevents energy losses, and prolongs the lifespan of urban assets. This paper highlights case studies of cities effectively implementing Big Data and Green IoT solutions, demonstrating tangible benefits such as cost savings, improved air quality, and enhanced quality of life for residents. Challenges such as data privacy, cybersecurity, and the need for robust regulatory frameworks.

Manuscript Information

- **ISSN No:** 2583-7397
- **Received:** 11-03-2025
- **Accepted:** 05-04-2025
- **Published:** 25-04-2025
- **IJCRM:**4(2); 2025: 322-326

- **Plagiarism Checked:** Yes
- **Peer Review Process:** Yes

How to Cite this Article

Shah AN. Development of environmentally sound smart cities with reduced energy consumption using Green Internet of Things and Big Data. Int J Contemp Res Multidiscip. 2025;4(2):322–326.

Access this Article Online

www.multiarticlesjournal.com

KEYWORDS: Big Data, Internet of Things, Green Internet of Things

1. INTRODUCTION

NOMENCLATURE

IoT – Internet of Things
GIoT – Green Internet of Things
NBIoT – Narrow Band Internet of Things
BD – Big Data
NFC – Near Field Communications
WSNs – Wireless sensor networks
ML – Machine Learning
NLP – Natural Language Processing
XAI – Explainable AI

Green Internet of Things (GIoT)

The term Internet of Things (IoT) was coined by Kevin Ashton in 1999. Ashton, who was working in supply chain optimization, wanted to attract senior management's attention to a new, exciting technology called RFID. Because the internet was the hottest new trend in 1999 and because it somehow made sense, he called his presentation the Internet of Things (IoT) [13]. The concept of the IoT has gained popularity since 2010. The IoT has a wider reach because it is connected to the industrial context as well as beyond the context of wearable devices [13]. The fundamental concept of the IoT is that everything around us, such as small rooms to large building, and human-made artifacts to natural objects, could be connected, sensed, and cooperatively communicated over the internet [14]. The IoT offers various services, but this may lead to environmental issues. These developments led to advancements in the field of IoT and gave birth to the Green IoT (GIoT). The green IoT is energy-efficient. The narrow band Internet of Things (NB-IoT) is an example of a GIoT. [15] The main aim of the GIoT is to achieve low energy consumption. [15]

Benefits of the GIoT

The deployment of the IoT in the real world is achieved through various technologies such as the internet, tags and sensors, including cloud computing, smart web services, mobile sensing, wireless sensors, nanotechnology, and near-field communications (NFC). By using the Green Internet of Things (GIoT), we can reduce energy consumption, reduce size, and reduce cost. Additionally, by using the Green IoT (GIoT), we can realize the true potential of WSNs by performing data communication at ultralow power and eliminating the power supply. For green cloud computing, we can design hardware that consumes less energy without losing quality, and we can design software that consumes less energy by minimizing the utilization of resources. [7]

Shortcomings of GIoT

The main purpose of the Green IoT is to reduce cost, reduce size, and reduce energy consumption, but the disadvantages of the Green IoT include high implementation costs, lack of information, lack of skilled human resources, uncertainty about performance, lack of available technology, lack of available materials, etc. [8]

Applications of the GIoT

Most of the applications of the GIoT are the same as those of the IoT, apart from its use for reducing energy consumption while ensuring that the environment is sound. [11] The applications of the GIoT include smart cities, smart energy, smart grids, smart transport, smart mobility, smart homes, smart buildings, smart factories, smart manufacturing, smart health, food and water tracking, smart logistics, and smart retail. [9, 11]

2. Big Data (BD)

Big data is data that is enormous and still growing in size with time. Data are large and complex, so none of the traditional database management tools can store and process them efficiently." [16] Here, the data may include structural data, semi-structured data, and unstructured data. Let us see each in detail.

Structured Data: Structured data is stored, accessed, and processed in a fixed format, such as tables in a relational database management system or, for example, a student table.

StudID	Name	Branch
S001	Amam	CE
S002	Krish	CE
S003	Veer	IT
S004	Love	IT
S005	Kush	BM

Table 1: Student Table

Unstructured Data

Any data with no fixed format is known as unstructured data. For example, data that combines simple text, images, and videos is combined. A prime example of unstructured data is the output returned by a Google search.

Semi-structured Data

Data that combines both structured and unstructured data is known as semi-structured data. In structured data, the order of attributes is important, while this is not the case for semi-structured data. An example of semi-structured data is an XML file or an RFID.

Currently, various companies use big data, such as Oracle, Google, SAP, Microsoft, Amazon, IBM, VMware, and Teradata.

Need for Big Data

Big data enables organizations to discover new opportunities, resulting in smarter business decisions, improved operational efficiency, increased profits, and greater customer satisfaction. Organizations can improve efficiency in numerous ways by using big data. For example,

[I] Utilizing company data helps identify the need for improvements in existing policies and processes.

[II] Utilizing customer data from social media, credit information, and consumer research to enhance or create new products and services.

Advantages of Big Data

The following are the different advantages of big data and big data analytics.

[I] Cost Saving: Leveraging Big Data with Hadoop and cloud technologies provides cost advantages to businesses. These tools are also useful for storing large amounts of data and identifying more efficient business operation methods.

[II] Time Reductions: Hadoop and in-memory analytics enable rapid identification of new data sources, allowing businesses to analyze data immediately and make quick decisions based on insights.

[III] New Product Development: By understanding customer needs and satisfaction trends, products can be developed that are tailored to their preferences.

[IV] Analyzing big data provides insights into current market conditions, allowing companies to produce products aligned with popular customer preferences and purchasing behaviors.
[V] Maintaining Reputation: Big data tools are also useful for analyzing feedback. So, you can identify who is saying what about your company. Therefore, accordingly, you can improve your business and maintain your reputation.
[VI] Fraud detection: Insurance companies leverage big data across their operations, particularly for fraud detection.

Disadvantages or Challenges with Big Data
Costs associated with hiring and training data scientists and big data experts are significant in the IT field, compounded by the challenge of establishing a Data Lake.
Data Quality: The main challenge is the data quality issue. Before any data is used for analysis, it must be accurate to make the right decisions. As per the survey, 60% of the time was spent by a data scientist on cleaning the data.
Security: Securing sensitive big data involves managing access, authentication, encryption, compliance, and audit trails, posing significant challenges for organizations.
Rapid change: Rapid change is a major drawback for big data analytics. Organizations spend money on one type of big data analytics technology after a few months of a new technology arriving at the market.
Skilled manpower: Highly skilled people are required for big data analytics.
Infrastructure: An organization requires infrastructure that can adopt big data. Some organizations use cloud technology but cannot eliminate infrastructure needs.
Ingesting data into a big data platform: Managing the influx of vast and increasing volumes of data daily presents challenges in simplifying and streamlining data access for companies.
Requirement of synchronization between data sources: Ensuring synchronization across diverse data sources is crucial for avoiding gaps and ensuring accurate insights and messaging in analytical platforms.

3. Usefulness of BDA in the development of smart cities
The integration of big data with IoT technologies is pivotal in the development of smart cities. Big data aggregates and processes vast amounts of information collected from various sources across the city, including sensors, RFID tags, and Bluetooth devices. These technologies enable continuous monitoring and real-time analysis of city infrastructure, traffic patterns, environmental conditions, and public services. By harnessing the IoT, cities can optimize resource allocation, improve public safety, enhance transportation efficiency, and mitigate environmental impacts. The synergy between big data and the IoT empowers city administrators and planners to make data-driven decisions, leading to urban environments that are both sustainable and adaptive. This integration not only enhances operational efficiency but also facilitates innovation in urban planning and governance, ultimately fostering the development of smarter, more liveable cities. A city is known as a smart city if it has a smart industry, smart grid (power supply), smart water management, smart health system, smart parking, smart transportation, smart home, smart people, smart police, etc.

All of the above features are possible only if we integrate big data with IoTs.
[I] Smart water management: In Da Nang, Vietnam, sensors provide real-time analysis of water quality, monitoring parameters such as pH and salt levels, and issuing alerts for any anomalies. This system reduces the reliance on manual data collection and testing, streamlines smart water management by detecting flow rates, and pollution levels, predicted water shortages, and minimizes leaks and wastewater overflow.
[II] Smart grid (power supply): The utilization of big data for smart grid environments helps to identify the supply level of electricity, forecast future power supply requirements, etc. This approach is also useful for reducing costs and improving management.
[III] Smart transport management: Big data plays a critical role in smart transport management, addressing major challenges in urban areas worldwide. It enables real-time access to information about public transportation via mobile devices and integrates sensors in vehicles to identify nearby parking availability.
[IV] Smart garbage management: Smart garbage management integrates sensors in bins to communicate with disposal centers, notifying individuals when bins are full. These data help optimize trash collection routes for efficient service delivery.
[V] Smart health system: Big data is used to provide personalized medical reports, used to identify high-risk patients, reduce hospital costs, reduce wait time, prevent fraud, etc. Along with AI it can be used to reduce the number of surgeries.
[VI] Smart governance: Big data analytics play an important role in enabling smart governance by informing effective policy-making based on insights into public needs across healthcare, social care, education, and more. Moreover, analyzing educational data from various institutes can aid in reducing unemployment.

LITERATURE SURVEY
The endeavor for resilient urban development has accelerated the integration of advanced technologies such as Big Data and the Green Internet of Things (IoT) in smart cities. [17] This literature survey reviews recent advancements, applications, and implications of these technologies in creating energy-efficient and environmentally sustainable urban environments. The Green IoT concept involves the deployment of IoT technologies with a focus on minimizing environmental impact. Perera *et al.* (2014) highlighted that the Green IoT aims to reduce energy consumption and carbon emissions through smart sensors and energy-efficient protocols.[3] Recent studies by Zhang *et al.* (2021) demonstrated the application of the Green IoT in smart grids, where real-time data from sensors enable precise energy distribution and load balancing, leading to significant energy savings. [12] Big Data technologies are pivotal in handling and analyzing the extensive data produced by IoT devices. Chen *et*

al. (2014) emphasize the importance of Big Data in uncovering patterns and insights that drive efficient urban planning and resource management. [4] The integration of Big Data with the IoT, as discussed by Kitchin (2014), enhances predictive analytics capabilities, enabling proactive measures for energy conservation and waste reduction. [5] Smart cities leverage the IoT and Big Data to enhance urban living while promoting sustainability. A study by Bibri and Krogstie (2017) explored how these technologies contribute to smart city frameworks, focusing on energy efficiency, transportation, and waste management. Their findings indicate that cities adopting these technologies experience improved environmental performance and reduced operational costs. [6] Several cities worldwide have successfully implemented green IoT and big data initiatives. For instance, Amsterdam's smart city project utilizes IoT-enabled infrastructure to monitor and optimize energy usage in buildings and public spaces, as detailed by the Amsterdam Smart City initiative (2019) [10]. Similarly, Barcelona's deployment of IoT sensors for smart lighting and waste management has led to significant energy savings and operational efficiency (Bakıcı *et al.*, 2013). [1] Despite the potential benefits, challenges remain in the extensive implementation of Green IoT and Big Data within smart urban environments. Issues such as data privacy, security, and the high cost of implementation are highlighted by Zanella *et al.* (2014). [2]. Subsequent research should prioritize developing standardized protocols, improving data security measures, and exploring cost-effective solutions to enable wider adoption. The incorporation of green IoT and big data technologies is pivotal for the development of sustainable smart cities. The current literature underscores the significant impact these technologies have on energy efficiency and environmental sustainability. As urban areas continue to grow, the implementation of these innovations will be crucial in addressing the challenges of modern urbanization and promoting sustainable development. Continued research and collaboration among stakeholders are crucial to address current challenges and fully harness the potential of big data and green IoT in smart cities.

CONCLUSION

The integration of Big Data and Green Internet of Things (IoT) technologies holds immense potential for the development of environmentally sustainable smart cities. By facilitating real-time monitoring, efficient resource management, and data-driven decision-making, these innovations can significantly reduce energy consumption and environmental impact. The synergy between the Green IoT and Big Data not only enhances urban infrastructure and service efficiency but also fosters a sustainable urban environment that can adapt to the growing demands of modern cities. This holistic approach is essential for building smarter, greener cities that prioritize sustainability and energy efficiency for future generations.

REFERENCES

1. Bakıcı T, Almirall E, Wareham J. A smart city initiative: the case of Barcelona. *J Knowl Econ*. 2013;4(2):135-48.
2. Zanella A, Bui N, Castellani A, Vangelista L, Zorzi M. Internet of Things for smart cities. *IEEE Internet Things J*. 2014;1(1).
3. Perera C, Zaslavsky A, Christen P, Georgakopoulos D. Sensing as a service model for smart cities supported by Internet of Things. *Trans Emerg Telecommun Technol*. 2014:1–12.
4. Chen M, Mao S, Liu Y. Big data: a survey. *Mob Netw Appl*. 2014;19:171–209.
5. Coutard O, Finnveden G, Kabisch S, Kitchin R, Matos R, Nijkamp P, *et al.* Urban megatrends: towards a European research agenda. 2014.
6. Bibri SE, Krogstie J. The core enabling technologies of big data analytics and context-aware computing for smart sustainable cities: a review and synthesis. *J Big Data*. 2017.
7. Shaikh FK, Zeadally S, Exposito E. Enabling technologies for green Internet of Things. *IEEE Syst J*. 2017;11(2).
8. Iravani A, Akbari MH, Zohoori M. Advantages and disadvantages of green technology; goals, challenges and strengths. *Int J Sci Eng Appl*. 2017;6(9).
9. Albreem MA, El-Saleh AA, Isa M, Salah W, Jusoh M, Azizan MM, *et al.* Green Internet of Things (IoT): an overview. *ICSIMA*. 2017.
10. Jameson S, Richter C, Taylor L. People's strategies for perceived surveillance in Amsterdam Smart City. *GeoJournal*. 2019;40(10):1467–84.
11. Ahmed R, Asim M, Khan SZ, Singh B. Green IoT—issues and challenges. *ICACSE*. 2019.
12. Zhang X, Manogaran G, Muthu BA. IoT enabled integrated system for green energy into smart cities. *Sci Direct*. 2021;46.
13. IoT Analytics. Internet of Things definition. Available from: https://iot-analytics.com/internet-of-things-definition/. Accessed 2024 Jun 23.

14. Shankar C. What is the difference between IoT and Green IoT? *Medium*. Available from: https://medium.com/@chaithrashankar0719/what-is-the-difference-between-iot-and-green-iot-e91917fc1df2. Accessed 2024 Jun 23.
15. IGI Global. Narrowband Internet of Things. Available from: https://www.igi-global.com/dictionary/narrowband-internet-of-things/89824. Accessed 2024 Jun 23.
16. Guru99. What is big data? Available from: https://www.guru99.com/what-is-big-data.html. Accessed 2024 Jun 23.
17. Prakash R, Singh G. Green Internet of Things (G-IoT) for sustainable environment. *Int J Multidiscip Res*. 2023;9(5):238–41.

About the Corresponding Author

Ankur N. Shah is working as an Assistant Professor at P P Savani University, Kosamba. With more than 16 years of experience across software industries and academic institutions, he has mentored numerous undergraduate and postgraduate students in their research and project work. He has authored several books at both national and international levels, delivered expert sessions, and contributed a chapter to a CRC publication. Ankur has published over 22 research papers and holds an Indian patent for a deep sentiment analysis system. Additionally, he is a member of the syllabus design committee at Saurashtra University and actively serves on the editorial boards of several international journals.