IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 6, June 2026

DOI: 10.17148/IJARCCE.2026.156103

The Impact of NoSQL Databases for Data Management and Analysis in Smart Cities

Nandini V[1], Jalaja M[2], Chaithra B P[3], Dr. Nagamani S[4]

Students, Department of Master of Computer Applications, SJB Institute of Technology, Bangalore, India[1-3]

Head of the Department, Department of Master of Computer Applications, SJB Institute of Technology, Bangalore, India[4]

Abstract: Smart city technologies generate massive amounts of data through IoT devices, transportation systems, healthcare services, surveillance systems, and smart energy platforms. Managing this continuously growing data using conventional SQL systems has become challenging, as they are primarily intended to manage structured data with predefined formats. NoSQL databases provide a modern solution by supporting scalable storage, flexible schema design, distributed computing, and real-time processing. This study explores how NoSQL databases support data management and analytical processes in smart city environments. Different NoSQL models such as document databases, key-value stores, column-family databases, and graph databases are discussed along with their applications in traffic management, healthcare monitoring, smart parking, and energy optimization. The study also compares SQL and NoSQL systems based on scalability, flexibility, and performance. The findings indicate that NoSQL databases provide efficient handling of large-scale and heterogeneous smart city data environments.

Keywords: NoSQL Database, Smart Cities, Big Data, MongoDB, IoT, Real-Time Analytics

I. INTRODUCTION

1.1 Background of the Study

Smart cities are becoming an important part of modern urban development. The adoption of technologies such as the Internet of Things (IoT), cloud computing, artificial intelligence, and big data analytics has changed the way cities manage operations and provide services to citizens. Modern urban environments generate huge volumes of urban data every second through surveillance cameras, healthcare systems, smart traffic networks, mobile applications, and environmental sensors.

Fig. 1. Smart City Infrastructure Using IoT and Connected Systems

Conventional SQL systems find it difficult to manage such large amounts of information because they are designed to process structured data with predefined formats. Smart city applications require flexible, scalable, and real-time processing systems capable of handling continuously changing datasets. NoSQL databases have emerged as an effective

DOI: 10.17148/IJARCCE.2026.156103

solution for managing smart city data because they support distributed architecture, schema flexibility, and high-speed processing. These features make NoSQL technologies suitable for large-scale urban applications.

1.2 Problem Statement

Traditional relational database systems often encounter challenges when processing the high volume, velocity, and variety of data generated in smart city environments. As a result, scalability, processing efficiency, and real-time data analysis may be affected.

1.3 Objectives of the Study

The major objectives of this research paper are:

- To understand how NoSQL databases support smart city applications
- To examine challenges involved in managing urban data efficiently
- To study the differences between SQL and NoSQL database systems
- To explore the use of NoSQL technologies in transportation, healthcare, and smart infrastructure
- To evaluate the benefits and limitations of NoSQL databases in real-time analytics environments

1.4 Scope of the Study

This study examines the role of NoSQL databases in smart city environments. It discusses their use in traffic monitoring, healthcare, parking management, energy management, and surveillance systems. The study also compares NoSQL databases with conventional SQL databases to evaluate their ability to manage and analyse the diverse types of data generated in modern cities.

II. LITERATURE REVIEW

NoSQL databases have become a key part of many smart city applications. Large amounts of data are generated by IoT devices and sensor networks, making it increasingly difficult for traditional databases to manage efficiently. NoSQL databases play a role in managing all the different types of data that smart cities produce. We are talking about data from traffic cameras, healthcare systems and environmental monitoring devices. The information generated in smart cities includes structured, semi-structured, and unstructured data. It is hard for traditional databases to manage it because they have a fixed way of storing data and are not very scalable. Some NoSQL databases, like MongoDB are really good at storing documents in a way, which makes them perfect for applications that need to work in real-time. Then there are databases like Cassandra which are great at storing data across many machines so they are always available and can handle a lot of data from sensors. We also have graph databases like Neo4j, which are used to study how things are connected in cities like traffic routes and public infrastructure. NoSQL databases are really good at handling a lot of data and performing well. There are still some issues that need to be worked out like security and making sure the data is consistent.

This study looks at how NoSQL databases can help smart cities manage their data better and do real-time analytics compared to traditional databases.

The fact that many IoT devices and smart technologies are being used in cities is making it really hard to manage all the data. Cities are using traffic systems, digital healthcare and sensor-based monitoring and all these systems are talking to each other all the time. We need databases that can handle all this real-time data and NoSQL databases are a choice because they are flexible and can handle a lot of data. Traditional databases just cannot keep up with the changing data and many organizations are switching to NoSQL databases for their storage and analytics needs. For this reason, many organizations are choosing NoSQL databases to achieve flexible data storage, distributed computing, and faster analytics in large-scale smart city applications.

III. METHODOLOGY

3.1 Overview of NoSQL Databases

NoSQL is a type of non-relational database used to manage large amounts of distributed data. Unlike traditional SQL databases, NoSQL databases support flexible schema designs and can store data in different formats. These include

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 6, June 2026

DOI: 10.17148/IJARCCE.2026.156103

document, key-value, column-family, and graph models. This flexibility allows NoSQL databases to handle large volumes of data efficiently across multiple systems.

The major features of NoSQL databases include:

- Flexible schema design
- High scalability
- Distributed architecture
- Faster read and write operations
- Efficient handling of unstructured data

3.2 Categories of NoSQL Databases

NoSQL databases are mainly classified into four categories:

- Document-Oriented Databases (MongoDB, CouchDB)
- Key-Value Databases (Redis, Riak)
- Column-Family Databases (Apache Cassandra, HBase)
- Graph Databases (Neo4j, ArangoDB)

Each database model is designed for specific data management requirements and analytics applications.

3.3 Proposed Smart City Data Architecture

The proposed system gathers information from various smart city technologies including intelligent traffic monitoring devices, digital healthcare platforms, surveillance networks, smart electricity meters, and sensor-based environmental monitoring systems.

The collected data is processed using NoSQL databases to support real-time analytics and intelligent decision-making.

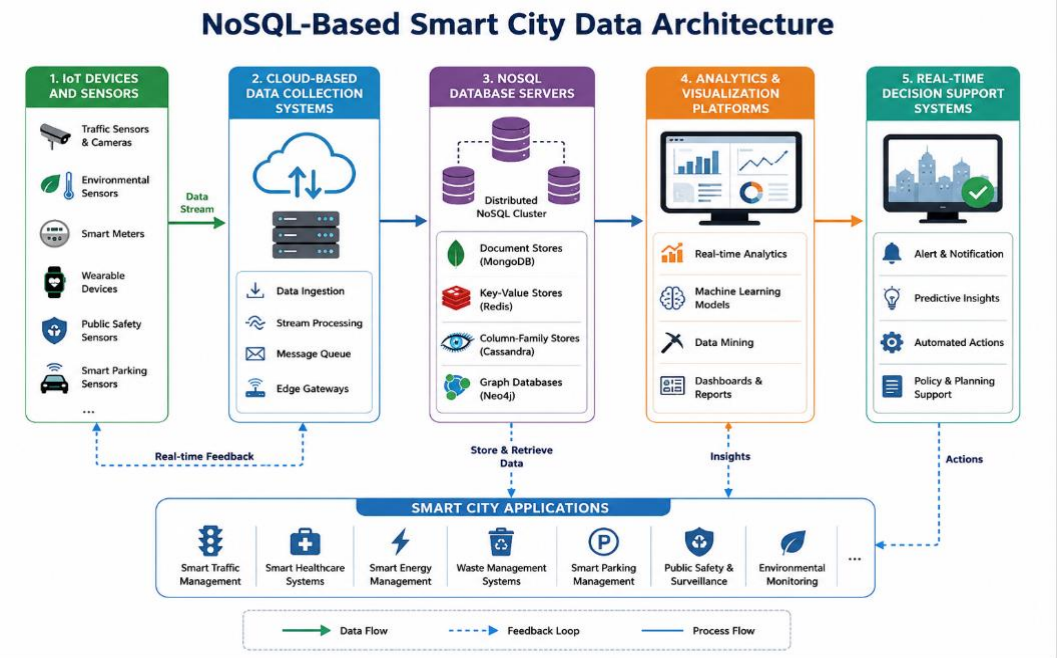

Fig. 2. NoSQL-Based Smart City Data Architecture

The architecture mainly consists of:

- IoT devices and sensors
- Cloud-based data collection systems
- NoSQL database servers
- Analytics and visualization platforms
- Real-time decision support systems

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 6, June 2026

DOI: 10.17148/IJARCCE.2026.156103

Advantages of the Proposed Architecture

The proposed NoSQL-based architecture helps manage large volumes of smart city data more efficiently. The distributed nature of NoSQL databases supports continuous data processing from multiple smart city devices without affecting system performance. Flexible schema models make it easier to store both structured and unstructured data collected from sensors, healthcare systems, transportation networks, and surveillance platforms.

Major advantages include:

- Efficient handling of large-scale real-time data
- Faster processing and data retrieval performance
- Flexible storage for heterogeneous smart city data
- Better scalability through distributed architecture
- Improved support for real-time analytics and decision-making

The proposed architecture helps smart city systems process rapidly growing urban data more effectively while supporting intelligent and automated city management services.

3.4 Working of NoSQL in Smart Cities

The process begins by collecting information from different smart city systems. The collected data is then sent to distributed databases, where it is processed and analysed in real time. The analysed information helps authorities improve traffic management, monitor healthcare services, use energy more efficiently, and enhance public safety. These activities are supported by the data collected from different smart city systems.

IV. RESULTS AND DISCUSSION

4.1 Smart Traffic Management

Traffic congestion is one of the major problems faced by modern urban cities. Smart traffic systems collect data continuously from GPS devices, traffic sensors, surveillance cameras, and connected vehicles. Handling continuously growing traffic information from connected urban systems requires database technologies that can process data quickly and support smooth real-time operations across multiple locations.

NoSQL databases provide faster data processing and flexible storage models that help traffic authorities monitor vehicle movement and optimize traffic flow efficiently. Real-time analytics also help emergency vehicles reach destinations quickly by reducing traffic delays.

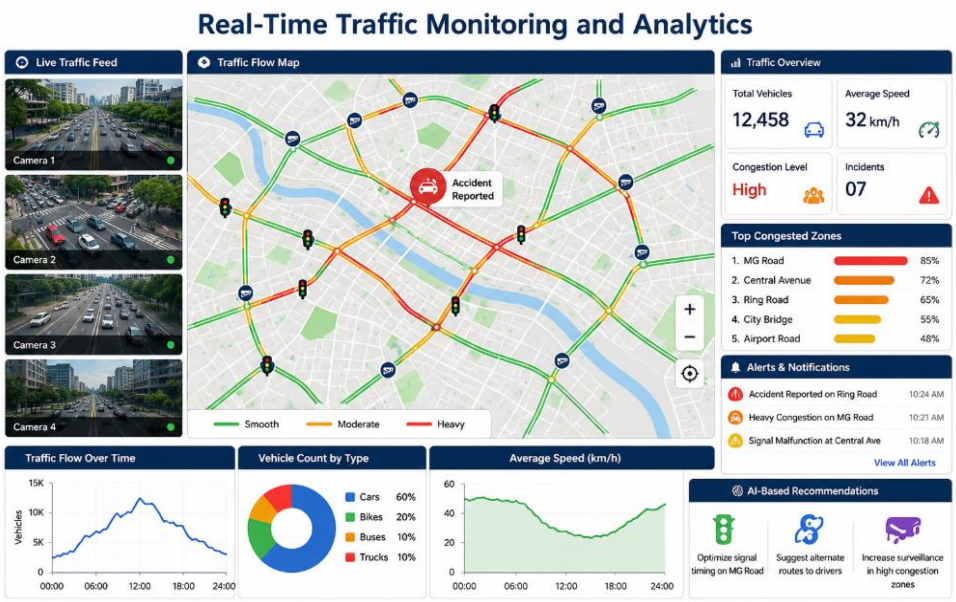

Fig. 3. Real-Time Traffic Monitoring and Analytics

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 6, June 2026
DOI: 10.17148/IJARCCE.2026.156103

The implementation of NoSQL databases in traffic management systems improves road safety, reduces congestion, and supports intelligent transportation planning. The collected data can be analysed instantly to identify high-traffic zones and optimize signal timing automatically.

4.2 Smart Healthcare Systems

Healthcare applications in smart cities generate large amounts of patient records, wearable sensor data, medical images, and emergency service information. Traditional databases often face difficulties while handling such continuously changing datasets.

NoSQL databases support flexible schema design and distributed data storage, allowing hospitals and healthcare organizations to manage patient information more efficiently. Real-time analytics can also help monitor patient conditions continuously and improve emergency healthcare response systems.

Benefits of NoSQL databases in healthcare systems include:

- Faster access to patient records
- Efficient management of medical data
- Real-time patient monitoring
- Improved healthcare analytics

4.3 Smart Energy Monitoring

Smart energy management systems use IoT-enabled smart meters and sensors to collect electricity consumption data from residential and commercial areas. These systems generate massive amounts of information every minute.

NoSQL databases provide scalable storage and faster processing for smart energy applications. Authorities can monitor power usage, detect faults, and optimize electricity distribution efficiently.

Applications include:

- Energy consumption monitoring
- Power usage optimization
- Fault detection systems
- Load balancing and energy analytics

The use of NoSQL technologies improves energy efficiency and supports sustainable smart city infrastructure development.

4.4 Smart Parking Management

Parking management is a problem in cities that are growing fast. In cities, drivers waste a lot of time looking for empty parking spots. This causes traffic and uses extra fuel. To solve this, smart parking systems use sensors, cameras, and technology to check whether parking spaces are free in real time.

Regular databases are not good at handling parking data, whereas NoSQL databases are. They process data quickly because they work across many computers. Parking sensors send data that is analysed to find available spaces and update their status immediately. Drivers receive this information on their phones or on digital display boards. This helps them find parking spaces easily and reduces unnecessary driving.

Smart parking systems rely on NoSQL databases to manage parking data efficiently. NoSQL databases make it easier to update parking space status, and drivers benefit from using parking systems that are supported by NoSQL databases.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 6, June 2026

DOI: 10.17148/IJARCCE.2026.156103

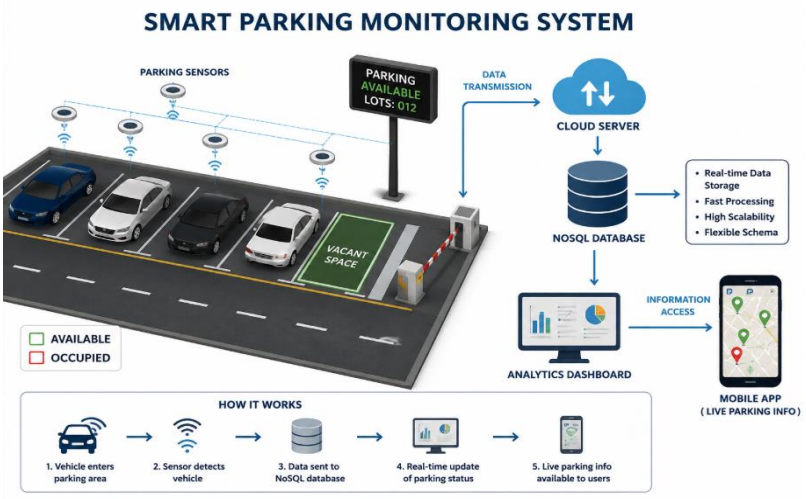

Fig. 4. Smart Parking Monitoring System

The implementation of NoSQL technologies in smart parking systems improves vehicle management, reduces unnecessary traffic movement, and minimizes fuel wastage. Real-time parking analytics also help city authorities optimize parking allocation and improve urban transportation efficiency.

Benefits of smart parking systems include:

- Reduced traffic congestion in urban areas
- Faster parking space identification
- Lower fuel consumption and pollution
- Improved vehicle movement management
- Better utilization of parking infrastructure

4.5 SQL vs NoSQL Comparison

The performance comparison between SQL and NoSQL databases shows significant differences in scalability, flexibility, and real-time processing capabilities. Traditional SQL databases perform well for structured datasets and transactional systems, whereas NoSQL databases are more suitable for handling heterogeneous and rapidly changing smart city data.

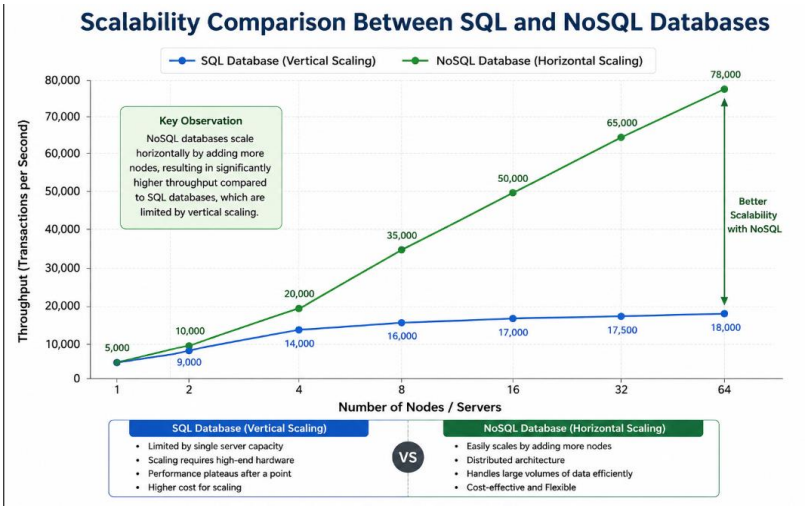

Fig. 5. Scalability Comparison Between SQL and NoSQL Databases

The comparison graph highlights that NoSQL database technologies can manage increasing smart city data more effectively than conventional SQL systems. Because of their distributed design and flexible architecture, NoSQL platforms maintain stable performance and support efficient large-scale data processing.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 6, June 2026

DOI: 10.17148/IJARCCE.2026.156103

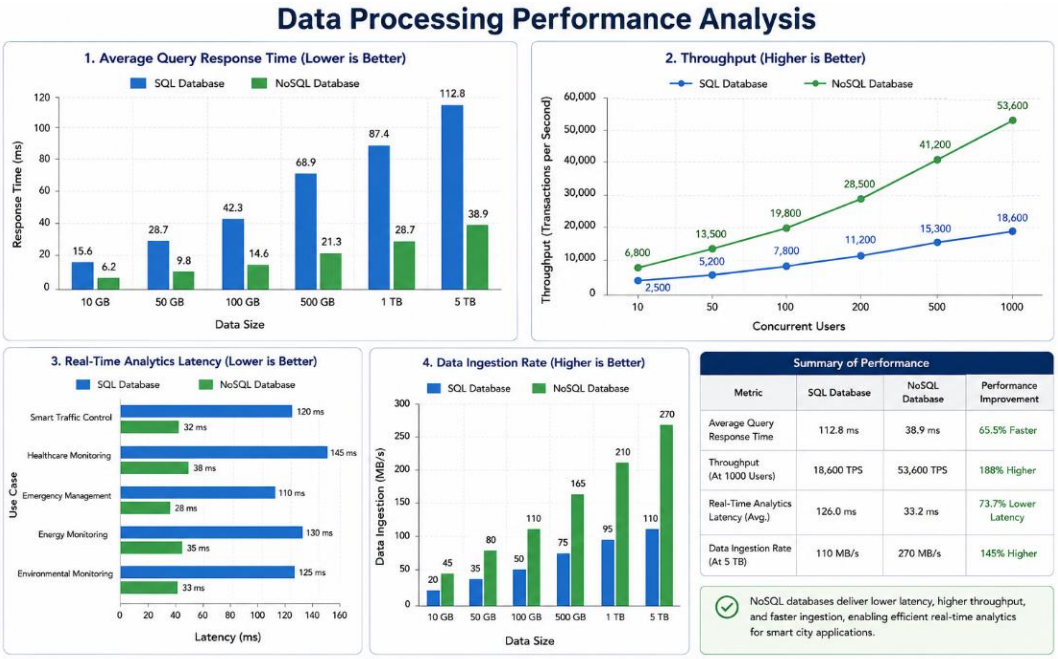

Fig. 6. Data Processing Performance Analysis

The performance analysis indicates that NoSQL databases provide lower latency and faster real-time analytics compared to traditional relational databases. These features are highly beneficial for applications such as smart traffic control, healthcare monitoring, and emergency management systems.

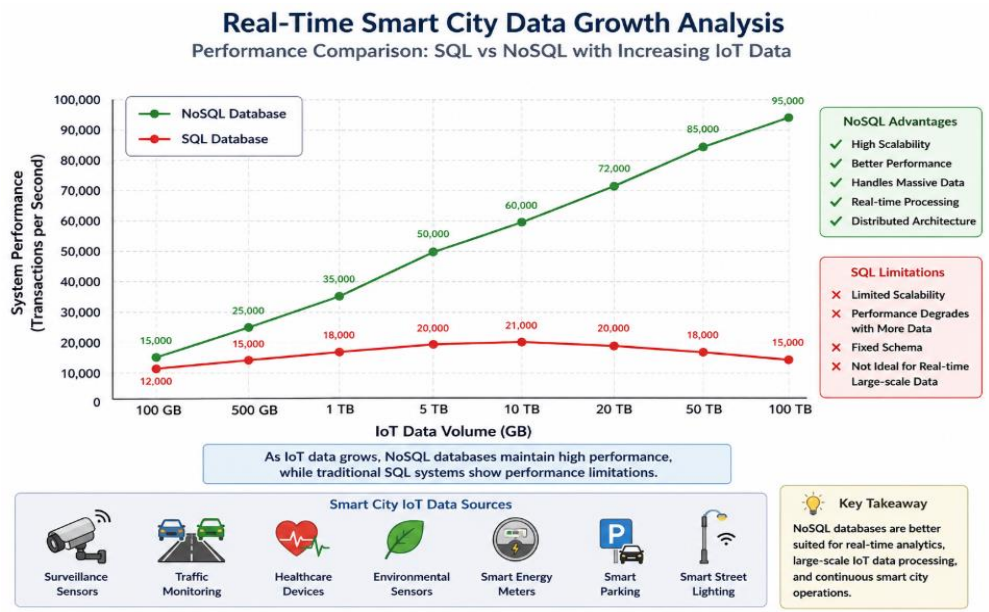

Fig. 7. Real-Time Smart City Data Growth Analysis

The graph compares the performance of SQL and NoSQL databases while handling continuously increasing IoT data generated in smart city environments. The analysis shows that traditional SQL systems experience performance limitations when data volume grows rapidly. In contrast, NoSQL databases maintain better scalability and faster processing performance because of their distributed architecture and flexible storage models.

The results indicate that NoSQL technologies are more suitable for applications requiring real-time analytics, large-scale sensor data processing, and continuous urban data monitoring. These capabilities make NoSQL databases highly effective for modern smart city infrastructures.

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 6, June 2026

DOI: 10.17148/IJARCCE.2026.156103

Table 1. Comparison Between SQL and NoSQL Database Technologies

Feature	SQL Databases	NoSQL Databases
Schema	Fixed Schema	Flexible Schema
Scalability	Vertical Scaling	Horizontal Scaling
Data Type	Structured Data	Structured & Unstructured Data
Performance	Moderate	High
Real-Time Analytics	Limited	Efficient
Data Storage	Tables and Rows	Documents, Graphs, Columns

The comparison clearly shows that NoSQL databases are better suited for smart city applications where scalability, flexibility, and real-time analytics are essential.

4.6 Advantages and Challenges of NoSQL Databases

Advantages:
- High scalability for large urban datasets
- Faster read and write operations
- Flexible schema management
- Better support for distributed systems
- Efficient handling of unstructured data
- Real-time analytics capabilities

Challenges:
- Security and privacy concerns
- Lack of standard query standards
- Complex distributed database management
- Limited ACID compliance in certain systems

Although NoSQL databases provide several advantages for smart city environments, organizations must address security and management challenges carefully during implementation.

The findings show that NoSQL technologies offer an efficient approach to managing large-scale and continuously growing smart city data. Features such as scalability, flexibility, and real-time processing make these databases suitable for supporting modern urban infrastructure.

V. CONCLUSION AND FUTURE WORK

Smart cities produce a lot of data from things like sensors, healthcare services, transportation systems, smart meters and surveillance cameras. It is hard to manage and look at this data with traditional databases because they are meant for information that is organized and does not change.

This study looked at how NoSQL databases can help with data management and analysis for smart city applications. It talked about how different NoSQL technologies can be used for things like transportation, digital healthcare, smart energy monitoring and connected urban infrastructure. NoSQL databases are really good for these kinds of things. When you compare SQL and NoSQL databases you can see that NoSQL databases are better for cities because they can handle a lot of data, are flexible and can store data in different places. They can also process data in real time which is important for smart cities. These features make NoSQL databases a good choice for handling large amounts of data that are always changing and come in different forms.

In the future we can work on combining NoSQL databases with artificial intelligence, machine learning and edge computing to make smart city systems even better. We can also do research on how to keep data safe, protect peoples privacy and use different types of databases together in big cities. Smart cities and NoSQL databases can work together to make cities better places to live.

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 6, June 2026
DOI: 10.17148/IJARCCE.2026.156103

REFERENCES

[1]. J. Han, E. Haihong, G. Le, and J. Du, "Survey on NoSQL Database," IEEE Conference on Pervasive Computing Applications, 2011.
[2]. M. Stonebraker, "SQL vs NoSQL Databases," ACM Journal, 2010.
[3]. C. Strauch, "NoSQL Databases for Distributed Data Storage," Stuttgart Media University, Germany, 2011.
[4]. J. Gubbi, R. Buyya, S. Marusic, and M. Palaniswami, "Internet of Things and Future Smart City Technologies," Future Generation Computer Systems, vol. 29, no. 7, pp. 1645–1660, 2013.
[5]. MongoDB Inc., "MongoDB Documentation," Available: https://www.mongodb.com
[6]. Apache Software Foundation, "Apache Cassandra Documentation," Available: https://cassandra.apache.org
[7]. A. Moniruzzaman and S. A. Hossain, "NoSQL Database for Big Data Analytics," International Journal of Database Theory and Application, vol. 6, no. 4, pp. 1–14, 2013.

