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IoT-Based Decision Support Systems for Smart Environments

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Abstract

IoT-based decision support systems have emerged as an important technological approach for transforming data generated by connected environments into actionable information for intelligent decision-making. The integration of Internet of Things devices, wireless sensor networks, cloud computing, edge computing, artificial intelligence, machine learning, and predictive analytics enables decision support systems to continuously collect, process, interpret, and communicate information from smart environments. This study examines IoT-based decision support systems for smart environments, focusing on sensing architectures, data integration, intelligent analytics, real-time decision support, predictive capabilities, automation, and application domains.

A qualitative descriptive and conceptual research design was adopted using secondary academic literature. The analysis indicates that IoT-enabled decision support can improve situational awareness, resource management, operational efficiency, responsiveness, and predictive decision-making across smart homes, healthcare environments, industrial facilities, agriculture, transportation, energy systems, and smart cities. IoT sensors provide continuous environmental and operational information, while edge computing supports low-latency processing and cloud platforms provide scalable analytical capabilities. Artificial intelligence and machine learning can identify patterns, detect anomalies, forecast conditions, and generate decision recommendations.

Despite these benefits, challenges related to data quality, interoperability, cybersecurity, privacy, system complexity, computational resources, and scalability continue to affect implementation. The study concludes that effective IoT-based decision support requires an integrated architecture combining sensing, communication, intelligent analytics, visualization, and automated or human-centered decision mechanisms. Future research should emphasize explainable AI, secure IoT architectures, edge intelligence, context-aware decision support, interoperable platforms, privacy-preserving analytics, and sustainable smart-environment infrastructures.

Keywords: Internet of Things, Decision Support Systems, Smart Environments, Artificial Intelligence, Machine Learning, Edge Computing, Smart Cities, IoT Analytics, Intelligent Decision-Making, Connected Systems

1. Introduction

The Internet of Things has transformed the development of smart environments by enabling physical objects, sensors, devices, and systems to communicate and exchange information. IoT technologies

provide continuous access to environmental and operational data, creating opportunities for more informed and responsive decision-making. However, collecting data alone does not guarantee effective decisions. IoT-based decision support systems address this limitation by combining connected sensing with data processing, analytics, visualization, artificial intelligence, and decision-support mechanisms. These systems can convert large volumes of heterogeneous information into useful insights for individuals, organizations, and automated processes.

Smart environments are characterized by interconnected devices capable of monitoring physical and operational conditions. Smart homes can collect information about energy use, occupancy, temperature, and security. Industrial environments can monitor machinery, production processes, and equipment conditions. Healthcare environments can collect information from connected medical devices and wearable sensors. Smart cities can monitor transportation, environmental conditions, energy consumption, and public infrastructure. Gubbi et al. (2013) identified sensing, communication, data processing, and intelligent services as important elements of IoT architectures. These characteristics provide a foundation for developing decision-support systems within connected environments.

Decision support systems have traditionally been developed to assist users in analyzing information and selecting appropriate actions. Power (2008) emphasized the role of decision support systems in providing computerized assistance for decision-making activities. IoT expands these capabilities by providing real-time information directly from physical environments. Instead of relying primarily on manually entered or historical information, IoT-based decision support can incorporate continuous sensor observations. This allows decision processes to become more dynamic, context-sensitive, and responsive to changing conditions.

Artificial intelligence and machine learning further enhance IoT-based decision support. Connected environments generate substantial quantities of structured and unstructured data that may contain patterns that are difficult to identify manually. Machine-learning algorithms can classify observations, identify anomalies, predict future conditions, and generate recommendations. AI-enabled decision support can therefore move from descriptive monitoring toward predictive and prescriptive decision-making. Russell and Norvig (2021) identified learning, reasoning, perception, and decision-making as central areas of artificial intelligence, all of which are relevant to intelligent IoT applications.

Edge computing has become increasingly important for IoT-based decision support because many smart environments require rapid responses. Sending all sensor information to remote cloud platforms can introduce latency and increase network traffic. Edge computing allows selected data-processing and analytical functions to be performed closer to the source of data. Shi et al. (2016) described edge computing as an approach that brings computation closer to network users and devices. In decision-support systems, edge intelligence can support immediate anomaly detection, local control, and time-sensitive recommendations.

Cloud computing remains important because smart environments can generate large amounts of data requiring scalable storage and processing. Cloud platforms can support centralized analytics, historical data analysis, model development, and cross-location information integration. Combining edge and cloud computing can provide a flexible architecture in which urgent decisions are processed locally while computationally intensive or long-term analytical tasks are performed through cloud resources. Such hybrid architectures can improve both responsiveness and scalability.

IoT-based decision support can contribute to resource optimization in smart environments. Energy systems can analyze consumption patterns and support demand management. Smart agriculture can use soil and environmental data to guide irrigation and resource allocation. Industrial systems can use equipment data to support predictive maintenance and production planning. Transportation systems can analyze traffic conditions to support routing and mobility decisions. These applications demonstrate that decision support can connect real-time observations with practical operational responses.

The increasing dependence on connected devices also creates concerns regarding cybersecurity and privacy. IoT devices may collect sensitive information and communicate across multiple networks and platforms. Unauthorized access, data manipulation, device compromise, and insecure interfaces can affect decision-support reliability. Security mechanisms must therefore protect devices, communication channels, analytical platforms, and decision outputs. Privacy is particularly important when smart environments collect information related to individuals, households, employees, or patients.

Interoperability is another major consideration. Smart environments may contain devices from different manufacturers using different communication protocols, data structures, and software platforms. If these systems cannot exchange information effectively, decision-support capabilities may become fragmented. Standardized interfaces, common data models, application programming interfaces, and interoperable communication protocols can improve integration. Effective decision support therefore requires not only intelligent algorithms but also reliable information exchange among heterogeneous IoT components.

Human involvement remains important even when IoT-based systems provide automated recommendations. Decision-support systems should provide users with understandable information regarding the basis of recommendations, confidence levels, and potential consequences. Explainability can improve trust and allow users to identify incorrect or unexpected outputs. Human-centered design is especially important in healthcare, industrial safety, energy management, and other applications where decisions may have significant consequences.

IoT-based decision support systems are therefore developing toward intelligent, context-aware, predictive, and increasingly autonomous platforms. Their effectiveness depends on the integration of sensing, communication, data management, analytics, decision modeling, visualization, and security. The objective is not merely to collect more data but to transform connected information into timely and useful decisions.

This study examines IoT-based decision support systems for smart environments by analyzing IoT architectures, intelligent analytics, edge and cloud computing, predictive decision-making, automation, and application domains. It also identifies major implementation challenges and future research opportunities. The study aims to provide a structured understanding of how IoT-enabled decision support can contribute to intelligent, responsive, secure, and sustainable smart environments.

2. Objectives of the Study

Primary Objective

The primary objective of this study is to examine IoT-based decision support systems for smart environments by analyzing connected sensing, data integration, artificial intelligence, machine learning, edge computing, cloud analytics, predictive modeling, and decision-support mechanisms. The study

seeks to understand how IoT-generated information can improve situational awareness, operational efficiency, resource management, responsiveness, prediction, and intelligent decision-making across diverse smart environments.

2.1 Examination of IoT-Based Decision Support Technologies

The first objective is to examine technologies supporting IoT-based decision support, including connected sensors, wireless communication, edge computing, cloud platforms, artificial intelligence, machine learning, predictive analytics, and visualization tools. The study evaluates how these technologies interact to transform sensor-generated data into useful decision information. Particular attention is given to real-time processing, data integration, intelligent recommendations, and context-aware decision mechanisms.

2.2 Assessment of Smart Environment Applications

The second objective is to assess IoT-based decision support applications in smart homes, healthcare, manufacturing, agriculture, transportation, energy systems, and smart cities. The study examines how connected data can support monitoring, forecasting, resource allocation, predictive maintenance, traffic management, energy optimization, environmental assessment, and operational planning. The objective also considers how decision-support capabilities can improve efficiency, responsiveness, and situational awareness.

2.3 Identification of Implementation Challenges

The third objective is to identify challenges affecting IoT-based decision support systems, including data quality, interoperability, cybersecurity, privacy, scalability, computational requirements, system complexity, and explainability. The study examines how these challenges influence decision accuracy, reliability, and user trust. Identifying these limitations can support the development of secure, transparent, scalable, interoperable, efficient, and user-centered decision-support architectures.

3. Review of Literature

3.1 IoT and Decision Support Systems

Gubbi et al. (2013) presented IoT as an architecture involving sensing, communication, data processing, and intelligent services. These capabilities create opportunities for integrating real-time physical information into decision-support systems. IoT-based decision support can continuously obtain information from connected devices and transform it into operational knowledge. This approach can improve monitoring and allow decision-makers to respond to changing environmental and organizational conditions more effectively.

Power (2008) examined decision support systems as computerized systems designed to assist decision-making activities. IoT introduces an additional real-time information layer by connecting decision-support mechanisms with physical environments. Instead of depending solely on static databases, IoT-based systems can incorporate continuous sensor observations. This capability can support dynamic decision-making, especially when environmental conditions change rapidly or when timely information is essential for operational management.

3.2 Artificial Intelligence and Predictive Analytics

Artificial intelligence can improve decision support by enabling systems to analyze complex information and identify patterns. Russell and Norvig (2021) described AI as a broad field encompassing learning, reasoning, perception, and intelligent action. Within IoT environments, these capabilities can be applied to anomaly detection, classification, forecasting, recommendation generation, and automated decision support. Machine learning can further improve system performance by learning from historical and continuously generated sensor information.

Predictive analytics enables IoT-based decision systems to move beyond monitoring toward forecasting. Sensor data can be used to estimate equipment failures, energy demand, traffic conditions, environmental changes, or resource requirements. Predictive models can support proactive decision-making by identifying potential future conditions before they become operational problems. However, predictive performance depends on data quality, model suitability, sufficient historical information, and continuous evaluation under changing environmental conditions.

3.3 Edge Computing and Smart Environments

Edge computing has become an important architectural approach for supporting real-time IoT decision-making. Shi et al. (2016) explained that edge computing moves computational resources closer to data sources and users. In smart environments, local processing can reduce latency and network traffic by filtering and analyzing sensor information near connected devices. This capability is useful for applications where immediate decisions or alerts are required.

Cloud computing complements edge processing by providing scalable computational and storage resources. IoT-based decision support can distribute processing between edge and cloud environments according to application requirements. Time-sensitive decisions can be handled locally, while complex historical analytics can be conducted through cloud infrastructure. This hybrid architecture can provide a balance between responsiveness, scalability, computational capacity, and centralized management.

4. Research Methodology

4.1 Research Design

This study adopted a qualitative descriptive and conceptual research design to examine IoT-based decision support systems for smart environments. The study was based on secondary academic literature concerning IoT, decision support systems, artificial intelligence, machine learning, edge computing, cloud computing, predictive analytics, and smart-environment applications. The design supports structured analysis of established technologies and their relationships within IoT-enabled decision-making architectures.

The conceptual framework considered sensing, communication, data integration, processing, intelligent analytics, decision generation, and action as interconnected components. These components were evaluated according to decision accuracy, responsiveness, scalability, reliability, efficiency, security, and usability. This framework enabled examination of how IoT technologies transform physical observations into information capable of supporting human or automated decisions.

4.2 Data Collection

Secondary data were collected from peer-reviewed journal articles, academic books, conference proceedings, and established scholarly publications related to IoT and intelligent decision support. Literature addressing IoT architectures, sensor networks, AI-based analytics, machine learning, edge computing, cloud platforms, predictive analytics, smart environments, and decision-support applications was considered.

The collected literature was organized according to technology and application themes. Technology categories included IoT sensing, communication, data management, edge computing, cloud computing, AI, machine learning, and visualization. Application categories included smart homes, healthcare, manufacturing, agriculture, transportation, energy, and smart cities. Studies addressing privacy, cybersecurity, interoperability, scalability, and explainability were also included.

4.3 Data Analysis

The literature was analyzed through thematic analysis to identify recurring technological and operational themes. Major themes included real-time sensing, intelligent analytics, predictive decision support, edge intelligence, cloud processing, resource optimization, cybersecurity, privacy, interoperability, and human-centered decision-making. Each theme was evaluated according to its contribution to IoT-based smart environments.

A comparative synthesis was used to examine the flow of information from connected devices to decision outputs. Sensors collect environmental information, communication networks transmit data, edge or cloud platforms process information, and AI-based models identify patterns or generate predictions. Decision-support mechanisms then provide recommendations or initiate automated actions. This process provided a structured basis for understanding IoT-based decision support as an integrated information and decision architecture.

5. Analysis

5.1 IoT Technologies Supporting Decision Support

IoT-based decision support depends on the integration of connected sensing, communication, processing, and intelligent analytics.

Table 1: IoT Technologies and Decision-Support Contributions

Technology	Primary Function	Decision-Support Contribution
IoT Sensors	Data acquisition	Real-time information
Wireless Networks	Data communication	Connectivity
Edge Computing	Local processing	Low-latency decisions
Cloud Computing	Scalable processing	Large-scale analytics
Artificial Intelligence	Intelligent analysis	Decision intelligence
Machine Learning	Pattern recognition	Prediction

Predictive Analytics	Forecasting	Proactive decisions
Visualization	Information presentation	User understanding

The analysis demonstrates that decision support is created through the interaction of multiple technologies. Sensors generate information, communication networks transmit observations, and computing platforms process data. AI and machine learning provide analytical capabilities, while predictive analytics supports forecasting. Visualization mechanisms present results to users in understandable forms. Together, these components enable decision-support systems to transform raw IoT observations into actionable information.

5.2 Smart Environment Applications

IoT-based decision support can support decision-making across diverse smart environments.

Table 2: IoT-Based Decision Support Applications

Smart Environment	Decision-Support Function	Potential Outcome
Smart Home	Energy and security management	Efficient operation
Smart Healthcare	Patient monitoring	Timely support
Smart Manufacturing	Equipment and production analysis	Process optimization
Smart Agriculture	Irrigation and crop decisions	Resource efficiency
Smart Transportation	Traffic analysis	Mobility improvement
Smart Energy	Demand forecasting	Energy management
Smart City	Urban monitoring	Improved planning
Smart Buildings	Environmental control	Efficient resource use

The analysis indicates that IoT-based decision support has broad applicability. Smart homes can use sensor information for energy and security decisions, while manufacturing environments can use equipment data for predictive maintenance. Agriculture can employ environmental observations for irrigation decisions, and transportation systems can use traffic information for route and mobility management. Smart cities can integrate multiple data sources to support urban planning and operational management.

6. Discussion

IoT-based decision support represents an important transition from data collection toward intelligent interpretation and action. Connected devices provide continuous information from physical environments, but decision-support mechanisms add value by processing that information and identifying meaningful patterns. This enables users and automated systems to move from reactive

responses toward more proactive approaches. The effectiveness of these systems depends on the quality, timeliness, relevance, and security of the information being processed.

Artificial intelligence and predictive analytics can significantly enhance IoT-based decision support. Machine-learning models can detect unusual patterns, forecast future conditions, and support recommendations based on historical and real-time data. Predictive capabilities are particularly useful for equipment maintenance, energy management, traffic planning, and environmental monitoring. However, AI models must be continuously evaluated because smart environments are dynamic and relationships between variables may change over time.

The combination of edge and cloud computing can provide a flexible infrastructure for intelligent decision support. Edge systems can process urgent information close to data sources, while cloud systems can perform large-scale analytics and long-term storage. This distributed approach can improve responsiveness while maintaining computational scalability. However, effective decision support also requires human-centered interfaces, explainability, security, and appropriate levels of automation. Decision systems should provide useful recommendations without reducing transparency or user control.

7. Challenges

7.1 Data Quality and Heterogeneity

IoT-based decision support depends on information generated by large numbers of connected sensors and devices. Sensor measurements can contain noise, missing values, inconsistencies, or calibration errors. Such problems can affect analytical results and reduce decision accuracy. Data preprocessing, validation, synchronization, and quality assessment are therefore necessary. Decision-support systems must also distinguish between reliable observations and potentially incorrect measurements before generating recommendations.

IoT environments frequently produce heterogeneous data using different formats, communication mechanisms, and collection frequencies. Combining these data sources can be technically complex. Differences in device capabilities and data structures can create integration problems. Standardized data models, interoperable interfaces, and appropriate data-transformation mechanisms can improve information integration. Developing architectures capable of processing heterogeneous IoT information remains an important implementation challenge.

7.2 Cybersecurity and Privacy

IoT-based decision support creates cybersecurity concerns because connected devices communicate through networks and often interact with cloud or edge platforms. Vulnerabilities in sensors, gateways, communication channels, or software can allow unauthorized access or data manipulation. Compromised information can directly affect decision outputs. Authentication, encryption, secure communication, access control, and continuous security monitoring are therefore essential for protecting IoT decision-support environments.

Privacy is particularly important when smart environments collect information about people, households, employees, or patients. Data may reveal behavioral patterns, locations, preferences, or operational activities. Organizations must implement appropriate data-management and access policies. Privacy-preserving techniques can reduce exposure of sensitive information while allowing useful

analytics. Maintaining a balance between data utility, decision accuracy, security, and privacy remains a significant challenge.

7.3 Scalability and Computational Requirements

Smart environments may contain thousands or millions of connected devices generating information continuously. Increasing network size can create substantial demands for storage, processing, communication, and device management. Centralized architectures may experience performance limitations as data volumes increase. Distributed edge-cloud architectures can help distribute computational workloads, but they also create additional coordination and management requirements.

AI-based decision support can require considerable computational resources, particularly when complex models process large volumes of sensor data. Resource-constrained IoT devices may not be capable of executing advanced models locally. Lightweight models, model compression, edge acceleration, and distributed processing can help address these limitations. Efficient allocation of computational tasks between devices, edge platforms, and cloud systems remains an important research issue.

7.4 Explainability and Interoperability

AI-based decision-support systems may generate recommendations that users cannot easily understand. Lack of explanation can reduce trust and make it difficult to identify errors. Explainable AI techniques can provide information about the factors influencing predictions or recommendations. Decision-support interfaces should communicate relevant evidence, confidence levels, and potential limitations. This is especially important when recommendations affect safety, health, finance, or critical infrastructure.

Interoperability is also essential because smart environments frequently combine devices, platforms, and applications from multiple sources. Incompatible protocols and data structures can prevent seamless information exchange. Standardized interfaces, common communication protocols, and interoperable data models can improve system integration. Greater interoperability can enable decision-support systems to combine information from multiple IoT domains and provide more comprehensive operational intelligence.

8. Future Research

Future research should focus on context-aware IoT decision-support systems capable of understanding environmental conditions and adapting recommendations accordingly. Research should investigate lightweight AI models for edge devices, real-time predictive analytics, adaptive learning, and multimodal sensor integration. Greater attention should also be given to systems capable of identifying changing conditions and modifying decision strategies without requiring extensive manual configuration.

Further research should explore explainable AI, privacy-preserving analytics, federated learning, secure IoT architectures, and interoperable decision-support platforms. Researchers should evaluate these systems in real-world smart environments over extended periods rather than relying only on laboratory experiments. Future studies should also examine sustainability, energy consumption,

computational efficiency, human trust, usability, and the social implications of increasingly automated decision-making.

9. Conclusion

IoT-based decision support systems provide an important mechanism for converting connected-environment data into useful information for intelligent decision-making. By integrating sensors, communication networks, computing platforms, analytics, and decision-support mechanisms, these systems can continuously observe physical and operational conditions. This capability can improve situational awareness and support more timely responses across diverse smart environments.

Artificial intelligence, machine learning, and predictive analytics significantly expand the capabilities of IoT decision support. These technologies can identify patterns, detect anomalies, forecast future conditions, and provide recommendations. Edge computing can support low-latency decisions close to data sources, while cloud computing can provide scalable processing and storage. Their integration creates flexible architectures for real-time and long-term decision-support requirements.

IoT-based decision support has applications across smart homes, healthcare, manufacturing, agriculture, transportation, energy, buildings, and smart cities. These systems can support energy optimization, equipment monitoring, resource management, traffic analysis, environmental assessment, and operational planning. Their benefits depend on reliable sensing, appropriate analytical models, effective communication, and user-centered decision interfaces.

However, data quality, cybersecurity, privacy, scalability, computational requirements, interoperability, and explainability remain important challenges. Poor-quality information can affect decision accuracy, while security vulnerabilities can compromise system integrity. Large-scale IoT environments create significant processing and management requirements. AI-based recommendations must also remain understandable and trustworthy for users.

Overall, IoT-based decision support systems have substantial potential to make smart environments more responsive, efficient, predictive, and intelligent. Future development should emphasize secure architectures, explainable AI, edge intelligence, privacy-preserving analytics, adaptive learning, and interoperability. Such developments can support decision-support systems that effectively connect real-time physical information with reliable human and automated decision-making.

References

1. Hajjaji, Y., Boulila, W., Farah, I. R., Romdhani, I., & Hussain, A. (2021). Big data and IoT-based applications in smart environments: A systematic review. *Computer Science Review, 39*, 100318. https://doi.org/10.1016/j.cosrev.2020.100318.
2. Syed, A. S., Sierra-Sosa, D., Kumar, A., & Elmaghraby, A. (2021). IoT in smart cities: A survey of technologies, practices and challenges. *Smart Cities, 4*(2), 429–475. . https://doi.org/10.3390/smartcities4020024
3. Rejeb, A., Rejeb, K., Simske, S. J., Treiblmaier, H., & Zailani, S. (2022). The big picture on the Internet of Things and the smart city: A review of what we know and what we need to know. *Internet of Things, 19*, 100565. . https://doi.org/10.1016/j.iot.2022.100565

4. Bellini, P., Nesi, P., & Pantaleo, G. (2022). IoT-enabled smart cities: A review of concepts, frameworks and key technologies. *Applied Sciences*, *12*(3), 1607. https://doi.org/10.3390/app12031607.
5. Whaiduzzaman, M., Barros, A., Chanda, M., Barman, S., et al. (2022). A review of emerging technologies for IoT-based smart cities. *Sensors*, *22*(23), 9271. . https://doi.org/10.3390/s22239271
6. Ikrissi, G., & Mazri, T. (2021). IoT-based smart environments: State of the art, security threats and solutions. *ISPRS Archives*, *XLVI-4/W5*, 279–286. https://doi.org/10.5194/isprs-archives-XLVI-4-W5-2021-279-2021.
7. Szum, K. (2021). IoT-based smart cities: A bibliometric analysis and literature review. *Engineering Management in Production and Services*, *13*(2). https://doi.org/10.2478/emj-2021-0017.
8. Zanella, A., Bui, N., Castellani, A., Vangelista, L., & Zorzi, M. (2014). Internet of Things for smart cities. *IEEE Internet of Things Journal*, *1*(1), 22–32.
9. Gubbi, J., Buyya, R., Marusic, S., & Palaniswami, M. (2013). Internet of Things (IoT): A vision, architectural elements, and future directions. *Future Generation Computer Systems*, *29*(7), 1645–1660.
10. Atzori, L., Iera, A., & Morabito, G. (2010). The Internet of Things: A survey. *Computer Networks*, *54*(15), 2787–2805.
11. Perera, C., Zaslavsky, A., Christen, P., & Georgakopoulos, D. (2014). Context aware computing for the Internet of Things: A survey. *IEEE Communications Surveys & Tutorials*, *16*(1), 414–454.
12. Botta, A., De Donato, W., Persico, V., & Pescapé, A. (2016). Integration of cloud computing and Internet of Things: A survey. *Future Generation Computer Systems*, *56*, 684–700.
13. Al-Fuqaha, A., Guizani, M., Mohammadi, M., Aledhari, M., & Ayyash, M. (2015). Internet of Things: A survey on enabling technologies, protocols, and applications. *IEEE Communications Surveys & Tutorials*, *17*(4), 2347–2376.
14. Whitmore, A., Agarwal, A., & Da Silva, L. M. (2015). The Internet of Things—A survey of topics and trends. *Information Systems Frontiers*, *17*, 261–274.
15. Minerva, R., Biru, A., & Rotondi, D. (2015). *Towards a Definition of the Internet of Things (IoT)*. IEEE Internet Initiative.
16. Stojkoska, B. L. R., & Trivodaliev, K. V. (2017). A review of Internet of Things for smart home: Challenges and solutions. *Journal of Cleaner Production*, *140*, 1454–1464.
17. Silva, B. N., Khan, M., & Han, K. (2018). Towards sustainable smart cities: A review of trends, architectures, components, and open challenges. *Sustainable Cities and Society*, *38*, 697–713.
18. Bibri, S. E., & Krogstie, J. (2017). Smart sustainable cities of the future: An extensive interdisciplinary literature review. *Sustainable Cities and Society*, *31*, 183–212.
19. Kitchin, R. (2014). The real-time city? Big data and smart urbanism. *GeoJournal*, *79*, 1–14.
20. Yigitcanlar, T., Kamruzzaman, M., Foth, M., Sabatini-Marques, J., Da Costa, E. M., & Ioppolo, G. (2019). Can cities become smart without being sustainable? A systematic review of the literature. *Sustainable Cities and Society*, *45*, 348–365.