iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 Issue: VI Month of publication: June 2025

DOI: https://doi.org/10.22214/ijraset.2025.73004

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue VI June 2025- Available at www.ijraset.com

Internet of Things for Environmental Management: A Review

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Abstract: The emergence of the Internet of Things (IoT) has developed an important technology of environmental management, which provides unprecedented functionalities for real-time sensing, data analysis, and automated control in a variety of ecological fields. This review combines studies of over 108 peer-reviewed publications (2014–2025) that were categorized within five application domains: (1) air quality monitoring, (2) precision agriculture and soil management, (3) water and wastewater monitoring, (4) wildlife and habitat conservation, and (5) smart-city integration. For each domain, we review system architectures, deployment case studies, performance numbers and bottlenecks—like energy harvesting, sensor calibration, interoperability, data security, and equitable access. Finally, we highlight remaining challenges and future work, such as Green IoT paradigm, edge-AI fusion, standardized evaluation protocols, and the novel participatory governance model, to enable scalable, sustainable and socially beneficial deployments.

Keywords: IoT; Environmental Monitoring; Air quality; Precision Agriculture;Water quality; Wildlife monitoring; Smart cities; Green IoT.

I. INTRODUCTION

The Internet of Things (IoT) is an emerging technology used to improve environmental management and sustainability. Through interlinked sensor networks, IoT enables the monitoring of key environmental parameters, e.g. the air quality, water pollution and temperature based on real-time (Gurbanova & Abdullayev, 2025; Elmustafa & Mujtaba, 2019). This technological architecture offers novel strategies for addressing urgent environmental problems, such as climate change, and scarcity of natural resources (Nur Aisyah Qadri Saiful et al., 2024; 23). Applications of IoT are wide ranging spanning from precision agriculture, solid waste management to natural resource preservation (Arya et al., 2023). However, their successful implementation is impeded by issues such as system integration, interoperability, and scalability (Usharani Hareesh Govindarajan et al., 2025; Čolaković & Hadzialic, 2018). The appearance of Green IoT is drawing attention to the need for sustainable technological strategies that focus on use of renewable energy and resource optimization (Jebur, 2022). Despite these concerns, IoT shows great potential, especially for advancing environmental sustainability and fostering data-driven decision-making across varied ecological settings.

II. IOT INTRODUCTION, UTILIZATION, AND ITS APPLICATION IN ENVIRONMENTAL MANAGEMENT

The Internet of Things (IoT) is an emerging paradigm that involves the integration of physical entities into the digital world using sensors and communication technologies (Basiron et al., 2017; Kushwah et al., 2020). Its architecture is typically divided into four main layers, namely, perception, network, processing, and application (Rana, 2025). IoT allows devices to automatically gather, exchange, and analyze data without human intervention, thus providing advanced automation and control (Dubey & Yadav, 2024; Khan & Yuce, 2019). Its usages are diverse including smart-homes, health care, transport systems, and industrial automats (Dubey & Yadav, 2024; Sutikno & Thalmann, 2022). While IoT provides many benefits, such as efficient operations and real-time monitoring, it also presents significant issues at the same time, such as security, privacy, interoperability, and scalability issues (Dubey & Yadav, 2024;;; Schoder, 2018). Future advances in 5G, artificial intelligence, and edge computing are poised to accelerate the maturation of the IOT phenomenon and pave the way for its increased integration and transformation across various industry (Kapoor & Mehra, 2025).

IoT has become a dominant paradigm for environmental monitoring through real-time data collection, analysis, and auto-responses to ecological problems (Gurbanova & Abdullayev, 2025; Shaikh, 2023). The IoT-based systems consist of environmental sensors, wireless communication networks, edge, and cloud computing as well as user interfaces to monitor vital statistics such as AQI, water contamination, and soil health (Shahu Teli et al., 2025; Shiny Abraham et al., 2017).

These technologies provide for real time monitoring that will supply the up to watch even remote and inaccessible areas to enhance the decision making and resource management (Shaikh, 2023; Arya et al., 2023). Furthermore, the use of machine learning algorithms makes it possible to discover significant patterns in the collected data which can be used in predictive modelling and to develop early warning systems (Chaitanya et al., 2024). However, while there are significant potential advantages that IoT can provide to environmental applications, there are still some major issues to be addressed, including data security, scalability, and system inter-operability (Govindarajan et al., 2025; Arya et al., 2023). IoT, however, provides a hopeful direction to develop a sustainable and proactive approach towards a sustainable future.

The advent of the Internet of Things (IoT) into environmental monitoring has disrupted data capture and analysis as it has virtually overcome the computational indebtedness of conventional methodologies (Rajesh et al., 2019; Shaikh Junaid Ahmad, 2023). IoT enables the real-time monitoring of various aspects of the environment such as air quality, water availability and soil (Gurbanova & Abdullayev, 2025; Suprava Ranjan Laha et al., 2022). Integrated IoT systems combined with AI further strengthen the predictive modelling potential as well as assist in automated decision-making and enhanced data accuracy (Tymoteusz Miller et al., 2025). This synergy leads to more efficient sustainability and adaptive natural resource governance (Nur Aisyah Qadri Saiful et al., 2024). However, there are still some problems to be solved, such as energy consumption, data security, and system stability (Guo Jinhao, 2025). To promote the full and sustainable implementation of IoT in environmental monitoring, future studies should focus on low-power system design, edge computing, and AI algorithm optimization (Jinhao Guo, 2025; Tymoteusz Miller et al., 2025).

The Internet of Things (IoT) has drastically revolutionised the field of environmental monitoring by facilitating the dynamic acquisition and processing of data in numerous backgrounds (Nur Aisyah Qadri Saiful et al., 2024; Mrs C. Radha et al., 2024). Its possible applications include the analysis of air and water quality, monitoring of weather patterns, wildlife migration, and the urban heat island effect (Mrs. C. Radha et al., 2024; Shaikh Junaid Ahmad, 2023). By combining all of these technologies, IoT improves sustainability, operational efficiency, and centricity of creativity in natural resource management (Nur Aisyah Qadri Saiful et al., 2024; Vishakha Agarwal et al., 2024). Tactical environmental surveillance using IoT ensures that the decisions are taken earlier to avoid an environmental risk and is an evidence-based policy (Biancha Katie, 2024). However, there are challenges such as its data security, system interoperability, and scalability. IoT presents a great potential in helping resolve today's urgent global environmental issues (Usharani Hareesh Govindarajan et al., 2025; Gurbanova Lala & Abdullayev Vugar, 2025). Recent studies have focused on the design of scalable IoT architectures to enhance interoperability and efficiency in pollution monitoring systems (Usharani Hareesh Govindarajan; Urga Jyothsna Medha/ Lavyatri Lahari Ravi et al., 2025) and the role of integrated approaches along with legal and statutory cues to decide on IoT deployment modes for the green IoT (Biancha Katie, 2024).

III. THE ROLE OF IOT IN THE MONITORING OF AIR QUALITY

IoT-enabled air quality sensing systems have revolutionized environmental monitoring by providing widespread deployment of low-cost sensors to obtain high resolution, real-time data (Barot & Kapadia and Paithankar, 2020; et al., 2023). These devices are usually implemented using small size sensors, which detect different gases, and the sensor components are integrated with wireless communication protocols. (Device description-Petrica et alare small size devices that include a sensor module for a number of air pollutants and wireless power-efficient communication- Ayat et al., 2024; Petrica et al., 2023) Compared to fixed monitoring infrastructure, IoT is presided to provide better spatial–temporal resolution at much lower cost (Zheng et al., 2016; Mokrani et al., 2019). Recent solutions have integrated new approaches, such as e-noses, energy efficient and low power wide area (LPWA) networks, to enhance the performance and coverage of the system (Ayat et al., 2024; Zheng et al., 2016). They are useful in indexing, analysing real-time data, and in fostering public participation in knowledge generation, awareness generation, and informed decision-making (Ramesh et al., 2024). However, several challenges including sensor calibration, data security, and energy-efficient solutions still persist (Ramesh et al., 2024). For further system improvement and enhance its capabilities, the future research perspective is proposed by the integration of artificial intelligence (AI) with both blockchain technologies and future 6G networks (Ramesh et al., 2024).

Recent research points to the promising potential of IoT technologies for air quality monitoring in cities. The use of cheap sensors and IoT platforms allows for continuous high-resolution real-time pollution mapping, resulting in the discovery of unknown pollution hotspots, and enabling mitigation efforts to be planned more systematically (Pendekanti et al., 2024, Múnera et al., 2021). Mobile sensing system (sensors attached to bicycles and drones) training with less devices can bring about sustainable and effective solution for distributed environmental sensing (Cetinkaya et al., 2021). By overcoming the constraints of conventional fixed monitoring stations, IoT-based systems can provide city-wide high-spatial-resolution air quality data reporting by cities and academic institutions (Mokrani et al., 2019; Barot & Kapadia, 2020).

These models amalgamate the pollutant concentrations, meteorological values, and predictive analytics to develop comprehensive air quality indices and prediction (Harish et al., 2021; Ramesh et al., 2024). The problem of data protection during transmission and its storage is addressed through improved communication protocols and cloud-based architectures (Toma et al., 2019). Inclusion of IoT-based air quality monitoring into smart city architecture underscore its imperative role for improving public health and enhancing environmental management strategies (Múnera et al., 2021); Ramesh et al., 2024).

The advantages of IoT-based air quality monitoring systems go beyond just improved data acquisition. Such systems enable long-term, real-time measurement of pollutant levels, aid in the characterization and quantification of pollution sources, and help in the assessment of spatiotemporal differences in air quality (Roshni Ramesh et al., 2024; Zheng et al., 2016). Fur- thermore, the frameworks can be used to inform the design of early warning systems and contribute to the evaluation of environmental interventions (Sivakumar et al., 2025). These systems also enhance data analysis and security by incorporating cutting-edge technologies, including AI, machine learning and blockchain (Pendekanti et al., 2024). Furthermore, IoT enabled platforms also could democratize air quality data access opening it to public scrutiny and allowing for the exploration of cleaner environments, based on founded real time evidence (Hsu et al., 2017; Kazembe & Mkandawire, 2024). Easy to understand interfaces, provide historical and live data about tracks to the general public which enhances their awareness and subsequent civic action on the issue (Roshni Ramesh et al., 2024; Múnera et al., 2021).

Although these technologies have the potential to be paradigm-shifting, there remain issues of data quality and sensor calibration (Buelvas et al., 2023; Ramesh et al., 2024). While low-cost sensors enable large-scale deployment, they introduce inaccuracies that must be accounted for using calibration techniques (Maag et al., 2018; Rai et al., 2017). A two-step calibration process (lab and field calibration) is recommended to have reliable data (Rai et al., 2017). In addition, the implementation of AI, blockchain, and edge computing can improve system performance, data security, and scalability (Ramesh et al., 2024; Sopruchi, 2025). Nevertheless, there is still a lack of a unified protocol for data integration from a variety of networks (Barot & Kapadia, 2020). Sensor technology is further developing by the inclusion of nano-materials to achieve high sensitivity, selectivity and long-life stability (Shahid et al., 2025). Notwithstanding these challenges, IOT enabled air quality monitoring system have a considerable potential to aid environmental health management and creation of public awareness on global scale (Sopruchi, 2025; Ramesh et al., 2024).

IV. OPPORTUNITIES AND CHALLENGES FOR IOT IN WILDLIFE CONSERVATION

The use of Internet of Things (IoT) has revolutionized wildlife conservation as it significantly improves monitoring and allows deeper understanding of animal behaviour (Khanna et al., 2023; Liu et al., 2015). IoT-based systems use GPS collars, sensor networks, and communication networks to monitor the location, physiological status, and environment in real time (Liu et al., 2015; Guo et al., 2015). In contrast to traditional methods, these technologies have the capacity for ongoing, wide-scale data collection that are necessary to inform leading-edge research and conservation activities (Dulari et al., 2020; Wall et al., 2014). Applications range from close-contact surveillance to geofencing, movement pattern characterization, or identification of immobility events (Wall et al., 2014). Despite their utility, IoT devices have long-standing issues including limited battery life, device heaviness, and data complexities (Reddy et al., 2023). Besides, for conservation and environmental threats such as habitat loss, illegal wildlife trade, human-wildlife conflicts IoT-based applications proved to be saviours (Choudhary, 2020). With technology being improved or advanced, IoT is hoped to be becoming more important in the wildlife conservation and ecology (Guo et al.,2015; Reddy et al.,2023).

The merging of Internet of Things (IoT) and AI has brought the conservation revolution, particularly the fight against wildlife crimes, to the next level.Further, the addition of artificial intelligence (AI) has further transformed conservation, such as in anti-poaching efforts. Actual integration is demonstrated in systems like EarthRanger and SMART that pool data from a number of sources to create real-time monitoring dashboards (Cronin et al., 2021; Wangmo et al., 2021). These instruments have shown significant enhancement in patrol efficiency and risk identification ability (Wangmo et al., 2021). IoT platforms integrated with machine learning models have indicated encouraging results towards the enhancement of surveillance operations and identifying poachers in African wildlife sanctuaries (Edemacu et al., 2019; Birari et al., 2025). For illustration, the PAWS system uses AI to forecast poaching risks and improve the patrol routes for rangers, which yielded promising results when they were tested in real national parks of various types (Gholami et al., 2019; Yang et al., 2014). In addition, such integrated systems allow for the real-time monitoring of wildlife health and the assessment of habitat status, and allow quick responses to emerging threats (Phalke 2024; Prof. Shilpa K C 2020). Overall, the coming together of the IoT and AI technologies has greatly accelerated attempts to protect wildlife and improve ecological management.

IoT solutions are becoming increasingly critical in the promotion of wildlife conservation and habitat monitoring. By embedding sensor networks in the natural environment, key environmental parameters can be monitored, animal movements observed, behavioural patterns studied (Liu et al., 2015; Dulari et al., 2020). These systems report in real time, allowing early detection of habitat degradation, disease, and illegal activities (e.g. logging and poaching; Khanna et al., 2023; Kumar, 2025). In general, monitoring devices using IoT technique consist of embedded sensors, communication networks and special software that take the advantages of data management software and data analysis software (Guo et al., 2015). Sophisticated machine learning code like Random Forest models, are currently used to analyze the scanning large data sets that provides accurate species identification and rich behavioral information (Roy et al., 2023; Ranganathan et al., 2025). The main IoT applications on wildlife conservation are geolocation tracking, habitat monitoring, and reducing human-wildlife encounter (Choudhary, 2020). However, despite the opportunities that IoT can offer for wildlife research and conservation, challenges remain in terms of deployment and optimization of such systems (Khanna et al., 2023; Choudhary, 2020).

Deploying IoT technologies for wildlife preservation poses particular challenges in severe and isolated conditions, challenging creative solutions. Energy limitations are being mitigated via kinetic energy harvesting approaches (Gregersen et al., 2023) and by ultra-low power devices (Ayele et al., 2019). The connectivity problem in isolated areas is addressed by using dual-radio opportunistic beacon networks (Ayele et al., 2019), and building LoRa-based communication infrastructures (Ayele et al., 2018). In addition, there is still a clear need for reducing the size of devices used for tracking smaller species, so as not to impact natural behavioural patterns or animal welfare (Reddy et al., 2023).

Ethical issues of IoT-enabled wild life monitoring concern the trade-off between knowledge and animal well-being and the protection against sensitive ecological information (Reddy et al., 2023). Advancements in tools such as sensors, RFID tags and GPSs have been critical in the development of holistic wildlife monitoring systems (Khanna et al., 2023), able to provide real-time tracking and monitoring comprising environmental and physiological data (Reddy et al., 2023). However, limitations associated with battery life, device weight, and the logistics of handling large data have so far acted as major roadblocks (Reddy et al., 2023). Moreover, persistent threats to the biodiversity—such as deforestation, fragmentation, and illegal activities—highlight the urgency of IoT enabled conservation approaches for the protection of wildlife and their habitats (Choudhary, 2020).

V. THE ROLE OF IOT IN PRECISION AGRICULTURE AND RESOURCE CONSERVATION

Recent works focus on the integrations of IOT technologies in precision agriculture, and discuss the changes that these technologies have brought about [2–4]. Soil monitoring systems enabled by the IoT use highly sophisticated sensors to monitor moisture level, temperature, the pH and the concentration of nutrients in the soil on a real-time basis (Oyedokun et al., 2025; Saha et al., 2023). These tools provide actionable information for optimizing irrigation, fertilization and crop management on the farm (Mansoor et al., 2025). When machine learning algorithms are integrated with IoT, it enhances predictive analytics and in turn, supports the design of crop recommendation models (Shukla & Agrawal, 2025, 2024). Uses of IoT in agriculture are resource utilization, farming process automatization and environmental sustainability (Baranitharan et al., 2024). The research also cited the advancement and application of remote sensing and decision making tools that enhances the data-driven agricultural practice (Kanwar, 2024). The accuracy of IoT based sensors can also be done by comparison of results of the sensors with other sensors that are used in soil and water quality as evidenced by (Bouhachlaf et al., 2023). Click here to download "Instructions to authors" Despite these advantages, factors including limited connectivity, data privacy and high initial cost of investment are til impediments for wide scale adoption (Mansoor et al., 2025; Baranitharan et al., 2024).

The IoT-based smart irrigation systems optimising the water resources for crop cultivation and productivity are revolutionising the agricultural water management and food-water nexus over the globe. Such systems comprise soil moisture measurements, weather monitoring stations, and real time data analytics for smart Water distribution (Shiva Mehta & Aseem Aneja, 2024; Aniket Nana Bagul, 2024). Field deployment documented moire water savings, anywhere from 20%-40% in the Central Valley, California, (Shiva Mehta & Aseem Aneja, 2024) to 50% in other agricultural regions (Sankari M et al., 2024) coupled with an increase in crop yield by up to 15% (Shiva Mehta & Aseem Aneja, 2024). IoT systems also allow remote monitoring and controlling using mobile apps; so that farmer can use the resources more efficiently (Paari A et al., 2025; Ali Abrar & Tukino Tukino, 2023). These applications are conducive to the sustainable use of agriculture as it saves water and cost (Aniket Nana Bagul, 2024). However, issues about system scalability, network diversity, possibility of security threat still serve as barriers against full scale adoption of the IoT applications in agriculture (A. A Raneesha Madushanki et al., 2019, Khaled Obaideen et al., 2022).

The convergence of IoT and artificial intelligence (AI) is changing precision agriculture through advanced crop monitoring and management techniques (Sharma & Shivandu, 2024; Chandran, 2021). IoT-based sensing systems use a network of sensors to collect real-time information regarding environmental conditions, soil properties and crop health, enabling the adoption of data-driven practices and utilization of resources in an optimal manner (Vitali et al., 2021; Chamara et al., 2022). Besides, high resolution camera equipped drones contribute aerial imagery to identify early indication of crop stress and disease, thus facilitating timely intervention (Gaonkar et al. These advances have resulted in notable impacts such as increased crop yield, improved water conservation, and reduced post-harvest losses (Anusha et al., 2025).

Apart from crop management, IoT use cases have also been extended to animal/ livestock farming using smart collars, automated feeders and health monitoring arrangements (Sodhi & Jamwal, 2024). Despite constraints such as poor network coverage and high costs of implementation, the integration of IoT with AI, robotics and blockchain potentially offers additional scope for the development of agriculture sustainability and productivity (Shrivastav et al., 2024;Anusha et al., 2025).

Precision agriculture, optimal resource management and green farming patters have been made possible through IoT-based innovations in the agricultural sector (Vijay Kumar et al., 2024; B. Baranitharan et al., 2024). Sensors, drones, and automatic gadgetry enable continuous observation of crop state, soil condition, or animal activity (Sewnet Getahun et al., 2024; Andrés Villa-Henriksen et al., 2020). Such technologies help to raise the levels of agricultural productivity, lower the episodes of environmental degradation, become important aid in the decision-making process (B. Bhavana et al., 2024). For instance, IoT based interventions have led to 30% decline in water use and minimal reliance on chemical fertilizers and pesticides (Vijayalakshmi Chintamaneni et al., 2024). Nevertheless, challenges in terms of connectivity, data security, and high initial cost still hinder widespread implementation (A. Narmilan & N. Puvanitha, 2020; Abdikarim Abi et al., 2024). Nevertheless, applications of IoT in agriculture offer considerable potential for the sustainable production of food combined with efficient use of resources, especially with AI, blockchain, and renewable energy solutions (B. Baranitharan et al., 2024; B. Bhavana et al., 2024).

VI. DATA ANALYTICS AND MACHINE LEARNING INTEGRATION IN IOT FOR ENVIRONMENTAL CONTROL

Advances in IoT technologies have revolutionized many aspects of environmental monitoring and management where sensor networks, cloud computing, and artificial intelligence (AI) are combined to extract actionable information from raw environmental data (Ficili et al., 2025; Krishnamurthi et al., 2020). These systems enable real-time decision making, predictive analytics, and optimal resources management strategies (Fang et al., 2014;Gomes et al., 2024). However, challenges in IoT-enabled environmental monitoring networks exist such as data quality, processing, and integration with systems. New methods, such as data fusion methodologies, advanced analytics and new computing paradigms, are being designed to overcome those limitations (Krishnamurthi et al., 2020; Sathyamoorthy et al., 2024). "The linkage of AI enhanced remote sensing technologies with IoT based networks has increased the accuracy and precision in environmental assessment and predictive ecosystem management (Arowolo et al., 2024). However, the interoperability and scalability challenges remain, because of which, more resilient and flexible IoT architectures need to be designed (Govindarajan et al., 2025). Notwithstanding these challenges, IoT-based environmental monitoring systems have become important tools for the understanding and control of complicated ecological processes (Chaitanya et al., 2024).

The convergence of Internet of Things (IoT) with machine learning (ML) has also been transforming environmental monitoring and water quality control. ML models are utilized to process huge amounts of IoT-acquired information and predict trends in water quality, anomaly detection and decision-support (Tymoteusz Miller, Shashank Y et al., 2024). These systems use different ML techniques, such as decision trees, random forests, and neural networks, to process complex environmental datasets well (Maria Silvia Binetti et al., 2024). Major parameters, including pH, turbidity and dissolved oxygen are monitored in real time by IoT sensor networks which then feed into the ML models for anomaly detection and predictive analytics (T. Leonila et al., 2024; Ismail Essamlali et al., 2024). The fusion of ML and IoT offers an accurate, low-cost and scalable solution for environmental monitoring (Mirjana Milutinović, 2024). Beyond water quality, this can be applied to air quality, climate change, and biodiversity conservation programs (Emran Alotaibi & N. Nassif, 2024; Rajvin Mehta & Kavish Devnani, 2021).

For environment IoT applications, recent works emphasize the increasing potential of reinforcement learning and federated learning. Reinforcement learning has also proven effective in the optimisation of resource allocation and control management strategies, especially in industrial systems and smart grid applications (Yaraziz & Hill, 2024; Mishra et al., 2023). In contrast, federated learning is a promising solution for the privacy concern in the distributed IoT environments by enabling joint model training without raw data sharing (Shristy & Kumar, 2024; Srinivas et al., 2024; Silva et al., 2023). Prominent applications are such as smart building energy management with federated learning based on improving thermal comfort with increased thermal demand predictions precision (Berkani, 2025).

In spite of these developments, the issues of data quality irregularity, model interpretability and computational resource constraints at the network edge continue to remain pronounced (Srinivas et al., 2024). To overcome these challenges, novel techniques such as differential privacy techniques, secure aggregation protocols and resource-efficient architectures are proposed to be developed (Srinivas et al., 2024; Shaik, 2024). Furthermore, the combination of IoT telemetry data with advanced analytics presents great potential for the enhancement of the work of environmental monitoring systems and causes a reduction in urban energy consumption (Hassan & Farea, 2025).

Future Perspectives on Smart-City Integration and Policy Frameworks on Sustainable IoT Deployments

Incorporating IoT techniques for inclusion in smart city is changing urban spaces through real-time acquisition of data and its analysis, that helps make better use of available resources which in turn improve quality of urban life ([[Bajaj2015]]) ([[Karthik Seetharaman2023]]) ([[Juneja2025]]). IoT applications are operated in various domains such as waste management, energy optimization, transportation systems and environment monitoring (Mr. Martin Jacob et al., 2023; Hassebo & Tealab, 2023). Moreover, green IoT initiatives are contributing to sustainable urban development by promoting energy efficiency and abating greenhouse gases (Nandhini et al., 2023; Dr. Shashank Singh et al., 2024).

However, the application of IoT in city environments brings about urgent challenges, including risks to data security, privacy issues, lack of interoperability (Caibo Wang, 2024; Idoko et al., n.d.). These challenges should be addressed in cooperation between the State, industry, and citizens, to secure a sound and equitable implementation (Hassebo & Tealab, 2023). Further research and development of future are

However, the future IoT devices will have to be energy efficient, advanced protocols have to be designed, and privacy-preserving mechanisms have to be built to support intelligent and sustainable urban ecosystems (Karthik Seetharaman, 2023).

VII. CONCLUSION

The combination of Internet of Things (IoT) and artificial intelligence (AI) is changing the landscape of environmental monitoring and control in various fields. IoT enables real-time monitoring and large-scale data mining service for air quality, water resources and ecosystem dynamics, and AI could improve the analytical ability because of the approaches such as predictive model and automatic decision support system. These innovations, taken together, support the move to more sustainable practices, greater operational efficiency, and more innovation in natural resources management.

However, it faces major technical, data management, as well as possible ethical issues related to data privacy and fairness. Provisions need to be implemented to address these challenges by developing scalable, resource-conserving approaches and stimulating interdisciplinary engagement in future work. This fusion of IoT and AI represents a new epoch for environmental stewardship and a transformative route to sustainability/resilience across multiple sectors.

Environmental Internet of Things (IoT-based) tools allow powerful mechanisms towards achieving sustainability and resilience in environmental management. Tracking critical indicators such as air quality, water resources, and ecological health in real time enables informed decision-making and pre-emptive action. IoT combined with AI and big data analytics can create predictive models, optimize resource use, and make targeted environmental improvements. However, the potential of these technologies cannot be fully exploited without overcoming challenges concerning data security, interoperability, and technological limitations. Environmental IoT initiatives will achieve greater success if they are integrated into wider environmental programs and are inclusive of diverse stakeholders and supported by flexible policy structures. This is a potentially powerful approach for advancing environmental monitoring, guiding sustainable resource management, and supporting the fight against global climate change.

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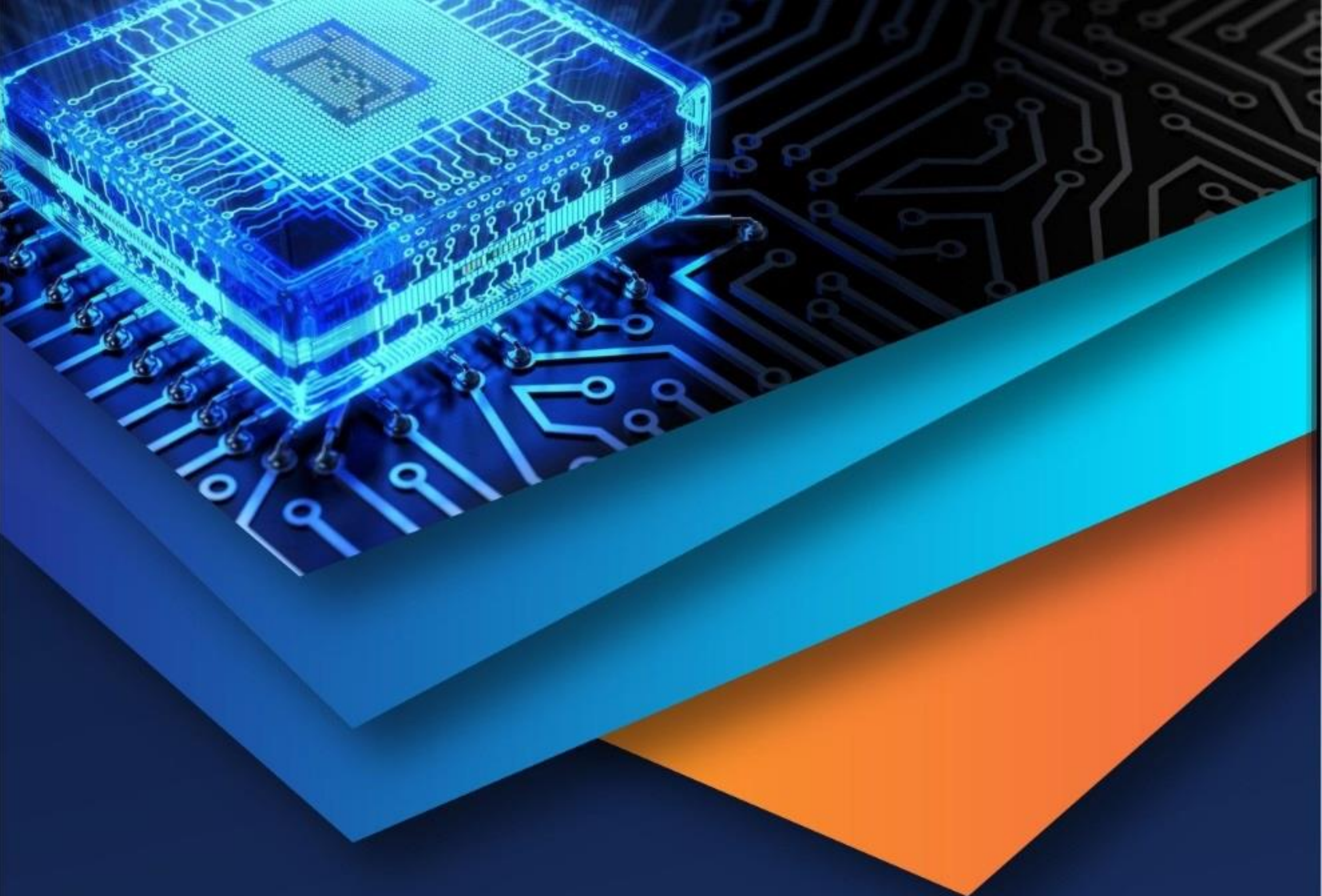

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