

Enhancement of Wireless Sensor Networks (WSN)

Using Artificial Intelligence (AI) and Internet of Things (IoT): A Review

Abhay Bhatia¹, Rajeev Kumar²

¹ Lincoln University College, Malaysia; ² Moradabad Institute of Technology, Moradabad

Email ID dhawan.abhay009@gmail.com

Abstract: Wireless Sensor Networks (WSN) have emerged as foundational infrastructure for modern intelligent systems, enabling real-time environmental monitoring, smart city management, precision agriculture, and industrial automation. However, traditional WSN architectures face persistent challenges including energy inefficiency, limited scalability, constrained bandwidth, and vulnerability to security threats. The convergence of Artificial Intelligence (AI) and the Internet of Things (IoT) with WSN presents transformative opportunities to overcome these limitations. This review article systematically examines recent advancements in the integration of AI-driven techniques—including machine learning, deep learning, and reinforcement learning—with IoT-enabled WSN platforms. The paper reviews routing optimization, anomaly detection, energy harvesting, edge intelligence, and security enhancement strategies. Furthermore, the review discusses emerging application domains spanning smart agriculture, smart cities, consumer electronics, and industrial systems. Ethical, privacy, and regulatory considerations are also critically analyzed. The findings indicate that AI-IoT-WSN convergence significantly improves network lifetime, data reliability, and decision-making accuracy, while simultaneously raising important questions around data governance and algorithmic fairness. Future research directions and open challenges are outlined to guide the next generation of intelligent sensor network design.

Keywords: Wireless Sensor Networks (WSN); Artificial Intelligence (AI); Internet of Things (IoT); Machine Learning; Edge Computing;

1. Introduction

The rapid proliferation of connected devices, sensors, and intelligent systems has fundamentally transformed the paradigm of network-based monitoring and control. Wireless Sensor Networks (WSN) constitute a critical enabling technology in this transformation, providing distributed sensing capabilities across diverse domains including environmental monitoring, healthcare, industrial automation, and precision agriculture. A WSN typically comprises a large number of low-cost, low-power sensor nodes capable of collecting, processing, and communicating data over wireless channels to a central gateway or base station [11].

Historically, WSN design focused primarily on hardware constraints—battery life, radio range, and data throughput. As applications have grown in complexity and scale, however, the demand for intelligent, adaptive, and autonomous network management has intensified. Traditional rule-based protocols and static routing algorithms are increasingly insufficient for dynamic, heterogeneous IoT environments characterized by fluctuating node density, unpredictable traffic patterns, and evolving security threats [6].

The emergence of Artificial Intelligence (AI) as a computational paradigm capable of learning from data, recognizing complex patterns, and making autonomous decisions has opened new horizons for WSN enhancement. Simultaneously, the Internet of Things (IoT) ecosystem has provided the architectural and communication scaffolding to deploy AI capabilities at the network edge, enabling real-time, context-aware decision-making without dependence on centralized cloud infrastructure [2]. Together, AI and IoT represent a synergistic enhancement layer for WSN—augmenting sensing with intelligence and connectivity with adaptability [9].

The significance of this convergence extends beyond technical performance metrics. It encompasses transformative societal applications: AI-IoT-WSN integration underpins smart city infrastructure, sustainable food systems, industrial safety monitoring, and e-commerce logistics [4, 8]. Yet these benefits are accompanied by critical challenges. Security and privacy vulnerabilities inherent in large-scale wireless deployments, combined with the ethical implications of AI-driven algorithmic decision-making, demand rigorous scholarly attention [3, 5].

Against this backdrop, this review article synthesizes contemporary research on AI and IoT-based enhancement of WSN. The review draws on a corpus of peer-reviewed publications spanning sensor network fundamentals, AI integration methodologies, application-specific deployments, and regulatory frameworks. By mapping the current state of knowledge and identifying gaps, this paper aims to provide a structured foundation for researchers, engineers, and policymakers engaged in next-generation intelligent sensor network design.

This paper is organized as follows: Section 2 provides foundational background on WSN architecture; Section 3 reviews AI methodologies applied to WSN; Section 4 examines IoT integration frameworks; Section 5 covers key application domains; Section 6 addresses security, privacy, and ethical dimensions; Section 7 discusses market and deployment perspectives; and Section 8 outlines future research directions before concluding remarks in Section 9.

2. Fundamentals of Wireless Sensor Networks

2.1 Architecture and Components

A standard WSN architecture consists of sensing nodes, a communication medium, and one or more sink nodes or base stations. Each sensor node integrates a sensing unit (transducers), a processing unit (microcontroller), a communication unit (radio transceiver), and a power unit (battery or energy harvester) [11]. The sensing unit converts physical phenomena—temperature, humidity, vibration, chemical concentration—into electrical signals suitable for digital processing.

Network topologies in WSN vary from flat peer-to-peer architectures to hierarchical cluster-based structures. In flat topologies, all nodes are homogeneous and communicate directly or via multi-hop relay with the base station. Hierarchical architectures introduce cluster heads—nodes with elevated processing and transmission capability—that aggregate data from ordinary nodes before forwarding it upstream. Hierarchical designs are generally more scalable and energy-efficient, making them the preferred choice for large-scale deployments [11].

2.2 Communication Protocols and Standards

WSN communication relies on low-power wireless standards including IEEE 802.15.4 (the physical and MAC layer specification underlying ZigBee), Bluetooth Low Energy (BLE), LoRaWAN, and NB-IoT. The selection of an appropriate protocol depends on application-specific requirements regarding range, data rate, power consumption, and network density. Routing protocols such as LEACH (Low Energy Adaptive

Clustering Hierarchy), PEGASIS, and AODV (Ad-hoc On-demand Distance Vector) govern how data traverses the multi-hop network from source to sink [12].

Notably, prior research by Bhatia et al. [12] demonstrated that MANET-based networked control systems employing AODV routing achieve reliable communication performance in dynamic topologies, highlighting the importance of adaptive routing in time-sensitive monitoring applications. These findings reinforce the case for intelligent routing solutions that can respond to real-time network state changes.

2.3 Energy Constraints and Lifetime Challenges

Energy consumption remains the paramount design constraint in WSN. Sensor nodes are often deployed in remote or inaccessible environments where battery replacement is impractical. Radio communication—particularly long-range transmission—dominates energy expenditure, followed by sensing and computation. Network lifetime, typically defined as the time until the first or a specified fraction of nodes deplete their energy reserves, is the central performance metric for WSN protocols [11]. Uneven energy distribution arising from traffic asymmetry (hot-spot problem), frequent retransmissions due to poor channel quality, and idle listening during periods of low activity all contribute to premature node failure. Balancing energy consumption across the network is therefore a fundamental objective of both routing protocol design and AI-based network management.

3. AI-Based Enhancement of WSN

3.1 Machine Learning for Routing Optimization

Machine learning (ML) has been extensively applied to WSN routing optimization, replacing heuristic protocols with data-driven policies capable of adapting to changing network conditions. Reinforcement learning (RL) is particularly well-suited to routing in WSN, where an agent (router node) learns an optimal forwarding policy through interaction with the network environment, maximizing long-term rewards defined in terms of energy efficiency, latency, and delivery ratio [6].

Q-learning and Deep Q-Network (DQN) variants have demonstrated superior performance compared to LEACH and similar conventional protocols in simulated WSN environments. These approaches enable nodes to autonomously adjust their cluster affiliation, transmission power, and sleep-wake schedules based on accumulated experience, leading to significant extensions in network lifetime [4]. Supervised learning approaches, including neural network-based link quality estimators, complement RL by providing accurate channel state predictions that inform proactive routing decisions.

3.2 Deep Learning for Anomaly Detection and Signal Processing

Deep learning architectures—convolutional neural networks (CNN), long short-term memory (LSTM) networks, and autoencoders—have been applied to WSN data streams for anomaly detection, fault diagnosis, and signal reconstruction. Given the noisy, incomplete, and potentially adversarial nature of sensor data in real-world deployments, robust anomaly detection is critical for maintaining data integrity and triggering timely alerts [2].

LSTM-based models excel at capturing temporal dependencies in multivariate sensor time series, enabling accurate detection of equipment failures, environmental hazards, and intrusion events. Autoencoder architectures trained on normal operating patterns identify anomalies by measuring reconstruction error, providing unsupervised detection capabilities that do not require labeled training data—a significant advantage in applications where anomalies are rare or poorly defined [10].

3.3 Federated and Edge AI

The deployment of AI at the network edge—on sensor nodes or local gateways—is increasingly recognized as essential for latency-sensitive and bandwidth-constrained applications. Edge AI eliminates the round-trip delay associated with cloud-based inference, enabling real-time response to critical events [9]. However, the computational and memory constraints of typical sensor hardware necessitate model compression techniques including weight pruning, quantization, and knowledge distillation.

Federated learning addresses the dual imperatives of model accuracy and data privacy by training ML models collaboratively across distributed sensor nodes without sharing raw data. Each node trains a local model on its own data and transmits only model updates (gradients) to the server for aggregation. This approach is particularly valuable in WSN deployments spanning multiple organizational domains, where data sharing is restricted by privacy regulations [6].

3.4 AI-Driven Energy Management

AI techniques have been applied to WSN energy management at multiple levels: node-level duty cycling, cluster-level load balancing, and network-level topology control. Predictive models trained on historical energy consumption and traffic patterns enable nodes to adaptively adjust their activity schedules, minimizing idle listening and unnecessary transmissions while ensuring sufficient coverage [4].

Decision support systems incorporating AI have demonstrated measurable improvements in WSN energy efficiency for consumer electronics and e-commerce applications. Basingab et al. [4] reported that AI-based decision support systems optimizing WSN for consumer electronics in e-commerce achieve significant reductions in energy consumption while maintaining high data delivery reliability, demonstrating the commercial viability of intelligent WSN management.

4. IoT Integration with WSN

4.1 IoT Architecture and Middleware

The IoT ecosystem provides the architectural framework within which WSN operates as a sensing substrate. IoT architecture is conventionally organized into three tiers: the perception layer (sensor nodes and actuators), the network layer (communication protocols and gateways), and the application layer (data processing platforms and user interfaces) [2]. WSN constitutes the primary instantiation of the perception layer, providing the raw data stream that feeds IoT analytics pipelines.

IoT middleware platforms—including MQTT brokers, CoAP servers, and cloud IoT services—facilitate data ingestion, normalization, storage, and dissemination from heterogeneous WSN deployments. These platforms support semantic interoperability across devices from different manufacturers and operating on different communication protocols, enabling the integration of WSN data into broader smart environment ecosystems [12, 19].

4.2 Cloud-Edge Continuum

The cloud-edge computing continuum represents the distributed infrastructure across which IoT-WSN data processing is allocated. Cloud computing offers virtually unlimited storage and compute resources for historical data analytics, model training, and cross-domain data integration. Edge computing—executed on gateways, base stations, or powerful cluster head nodes—provides low-latency, bandwidth-efficient processing for time-critical applications [9].

Fog computing occupies an intermediate layer, providing distributed processing nodes between the cloud and the network edge. In AI-enhanced WSN deployments, the fog layer is increasingly used for model inference and local decision-making, reserving cloud resources for model training and global optimization.

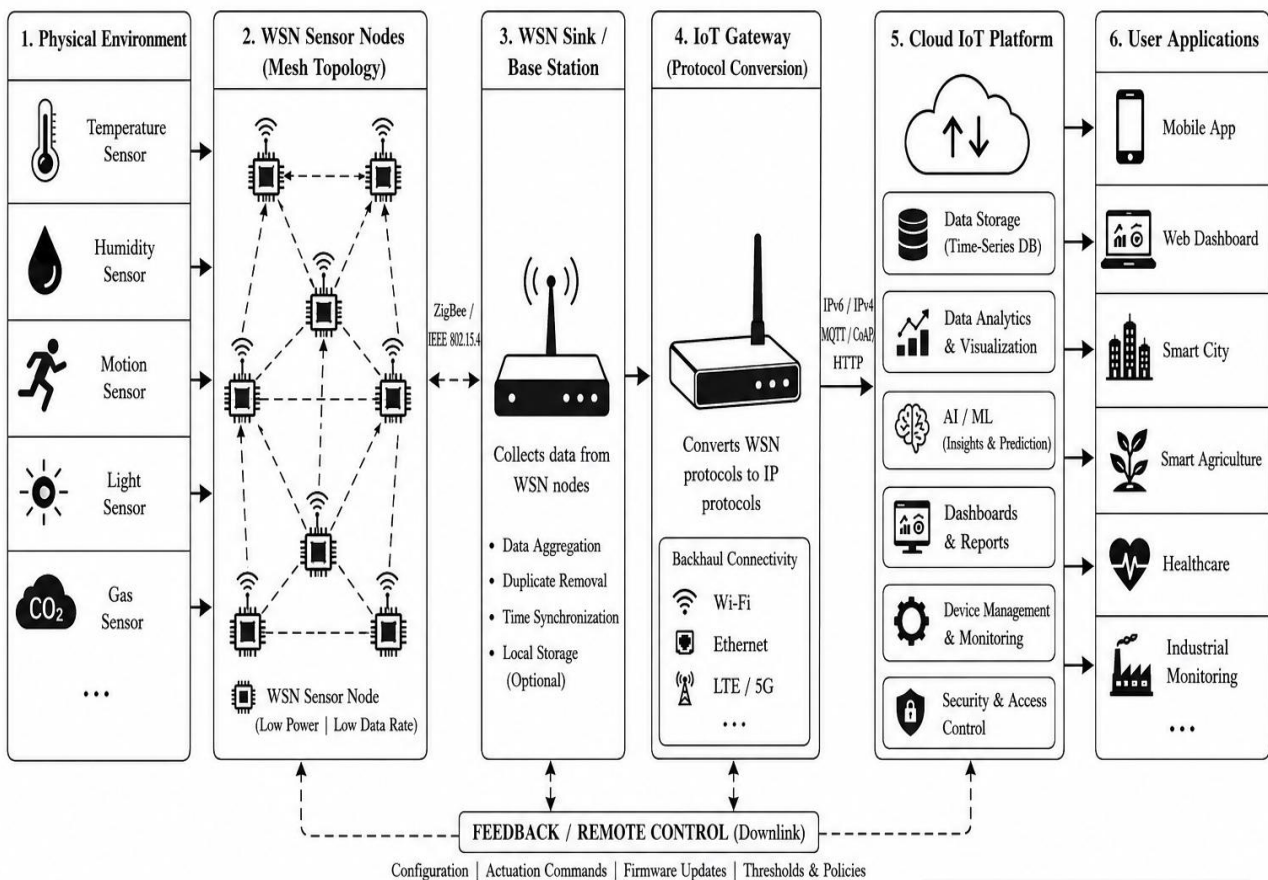
This hierarchical distribution of intelligence is essential for scalable deployment of AI-WSN systems across smart city and industrial environments [2].

4.3 Interoperability and Standardization

Interoperability remains a significant challenge in large-scale IoT-WSN deployments. Heterogeneous hardware platforms, proprietary communication protocols, and incompatible data models impede seamless integration across organizational and domain boundaries. Standardization efforts by IEEE, IETF, and industry consortia (including the oneM2M standard and the Matter protocol) are progressively addressing these gaps, but widespread adoption of unified frameworks remains a long-term objective [2, 3].

Semantic web technologies, including OWL ontologies and SPARQL-based data querying, are being explored as solutions for semantic interoperability in heterogeneous IoT-WSN systems. These approaches enable machines to interpret and reason about sensor data according to shared conceptual models, facilitating automated data integration and intelligent service composition in multi-vendor environments [10].

IoT Integration with Wireless Sensor Networks (WSN)



5. Application Domains

5.1 Smart Agriculture and Sustainable Food Systems

Precision agriculture represents one of the most impactful application domains for AI-IoT-WSN integration. WSN deployed across agricultural fields continuously monitor soil moisture, temperature, pH,

nutrient levels, and microclimatic conditions, enabling data-driven irrigation scheduling, fertilization optimization, and pest management [1]. AI analytics applied to these sensor streams facilitate early detection of crop stress, disease outbreaks, and irrigation inefficiencies that would otherwise go undetected until significant yield loss has occurred.

Han, Benson, and Abon [1] highlight the ethical dimensions of WSN deployment in sustainable agriculture, including data ownership concerns for smallholder farmers, algorithmic bias in predictive models trained on data from large commercial farms, and the digital divide that may exclude resource-constrained farming communities from the benefits of precision agriculture technology. These ethical considerations underscore the importance of inclusive design principles and participatory technology development in agricultural WSN deployment.

5.2 Smart Cities and Urban Infrastructure

Smart city applications represent the largest and most diverse domain for AI-IoT-WSN deployment. Applications span traffic management, structural health monitoring of bridges and buildings, air and water quality monitoring, waste management optimization, and public safety surveillance [2]. The scale and density of urban WSN deployments—potentially involving millions of nodes across metropolitan areas—necessitate highly scalable, AI-driven network management solutions.

Arfanuzzaman [8] demonstrates that AI and big data technologies, when applied to smart city sensor infrastructures, can significantly advance progress toward Sustainable Development Goals (SDGs) in South Asian urban contexts. The findings highlight the potential of AI-WSN integration to improve resource efficiency, reduce environmental impact, and enhance quality of life in rapidly urbanizing regions, while cautioning against the risks of technology-driven exclusion of marginalized urban populations.

5.3 Industrial IoT and Manufacturing

Industrial WSN deployments support predictive maintenance, process optimization, worker safety monitoring, and supply chain visibility in manufacturing and energy production environments [10]. The Asia-Pacific industrial wireless sensor network market has shown robust growth, driven by increasing automation adoption across manufacturing sectors in China, Japan, South Korea, and emerging economies such as India and Vietnam [7]. Market projections for 2025-2032 indicate sustained expansion as Industry 4.0 adoption accelerates.

AI techniques including vibration signature analysis, thermal imaging correlation, and multi-modal sensor fusion enable predictive maintenance models to detect incipient bearing failures, electrical faults, and structural degradation weeks or months before catastrophic failure, dramatically reducing unplanned downtime and maintenance costs [10, 11].

5.4 Consumer Electronics and E-Commerce

AI-based WSN integration in consumer electronics and e-commerce logistics encompasses smart home automation, retail inventory monitoring, cold chain management, and last-mile delivery optimization. Basingab et al. [4] proposed an AI-based decision support system integrating WSN with e-commerce platforms that optimizes network parameters dynamically based on real-time traffic demands, demonstrating significant improvements in both network performance and energy efficiency compared to static configuration approaches.

6. Security, Privacy, and Ethical Considerations

6.1 Security Threats in AI-IoT-WSN

The distributed, open-access nature of wireless communication renders WSN inherently vulnerable to a range of security threats, including eavesdropping, node capture, Sybil attacks, denial-of-service (DoS) attacks, and routing manipulation [3]. The integration of AI introduces additional attack surfaces: adversarial machine learning attacks that manipulate model inputs to produce erroneous predictions, model poisoning attacks that corrupt federated learning aggregation, and model inversion attacks that reconstruct sensitive training data from deployed models.

Sonti et al. [3] provide a comprehensive review of current security solutions for IoT and sensor networks, encompassing lightweight cryptographic protocols, intrusion detection systems, secure key management schemes, and trust-based routing mechanisms. The review identifies persistent gaps in resource-constrained node authentication, secure firmware update mechanisms, and standardized security certification frameworks for IoT-WSN devices.

6.2 Privacy in AI-Driven WSN

Privacy preservation in AI-enhanced WSN encompasses multiple dimensions: data minimization (collecting only the minimum data necessary for the intended purpose), anonymization (removing or obfuscating personally identifiable information from sensor streams), and access control (ensuring that data is accessible only to authorized parties) [5]. In pervasive urban sensing deployments, the aggregation of individually innocuous sensor measurements can enable sensitive inferences about individuals' behavior, location, and health status—a phenomenon known as the aggregation problem.

Pan et al. [5] examine the ethical implications of AI algorithms for news recommendation systems supported by wireless sensing technology, demonstrating how sensor-derived behavioral signals can inadvertently reveal users' political preferences, personal relationships, and psychological vulnerabilities. The paper proposes a framework of coping strategies encompassing algorithmic transparency, differential privacy, and user-controlled data sharing, offering guidance applicable to a broad range of AI-WSN applications.

6.3 Ethical Frameworks and Regulatory Compliance

The deployment of AI systems in WSN-enabled environments raises fundamental ethical questions regarding informed consent, algorithmic accountability, and equitable access to technology benefits [1,5]. Regulatory frameworks including the European Union General Data Protection Regulation (GDPR) and emerging AI governance frameworks impose requirements for data minimization, purpose limitation, and explainability of AI-driven decisions that directly affect WSN system design [3].

The principle of privacy-by-design—embedding privacy protection mechanisms into the architecture of sensor networks from the outset, rather than as an afterthought—is increasingly recognized as essential for compliant and trustworthy WSN deployment. This principle mandates proactive rather than reactive privacy management, end-to-end security rather than perimeter defence, and full functionality without privacy trade-offs wherever technically feasible [9].

7. Market Landscape and Deployment Perspectives

The global wireless sensor network market is experiencing sustained growth, driven by increasing adoption across industrial, agricultural, smart city, and healthcare domains. The Asia-Pacific region is a particularly dynamic market, with industrial WSN deployments expanding rapidly in response to rising

manufacturing automation, government-led smart city initiatives, and growing agricultural technology adoption [7].

Conseagic Business Intelligence [7] projects continued expansion of the Asia-Pacific industrial WSN market through 2032, driven by favorable government policies supporting digital transformation, declining sensor hardware costs, and increasing availability of cloud and edge computing infrastructure. Emerging economies including India, Vietnam, and Indonesia are identified as high-growth markets, reflecting expanding manufacturing bases and urban development programs.

The integration of AI capabilities into WSN products—both through cloud-based analytics services and embedded edge AI hardware—is increasingly seen as a key market differentiator. Vendors offering AI-enhanced WSN solutions report higher customer retention rates and greater deployment scale compared to conventional sensor network offerings, reflecting the value customers place on intelligent, self-managing network capabilities [20, 21].

8. Summary of Key Literature and Research Gaps

Table 1 provides a structured synthesis of the key literature reviewed, mapping each source to its primary contribution, domain focus, and identified research gap or limitation.

Table 1: Summary of Reviewed Literature

Ref.	Authors / Source	Key Contribution	Domain Focus	Research Gap / Limitation
[1]	Han et al. (2025)	Ethical framework for WSN in sustainable agriculture	Precision Agriculture	Limited empirical validation; focus on high-income farming contexts
[2]	Alahi et al. (2023)	IoT-AI integration for smart city infrastructure	Smart Cities / IoT	Insufficient treatment of edge AI deployment constraints
[3]	Sonti et al. (2025)	Security & privacy challenges in IoT sensor networks	Cybersecurity / IoT	Lack of standardized benchmarks for IoT security evaluation
[4]	Basingab et al. (2024)	AI decision support for WSN in e-commerce electronics	Consumer Electronics	Simulation-only validation; real-world deployment not covered
[5]	Pan et al. (2023)	Ethical AI in news recommendation via wireless sensing	Media / Sensors	Narrow domain; broader WSN privacy implications not addressed

Ref.	Authors / Source	Key Contribution	Domain Focus	Research Gap / Limitation
[6]	Ahmad et al. (2021)	AI challenges and opportunities in wireless IoT networks	IoT / AI	Rapid field evolution; some findings now superseded
[7]	Consegi BI (2025)	Asia-Pacific industrial WSN market forecast 2025-2032	Market Analysis	Proprietary data; limited methodological transparency
[8]	Arfanuzzaman (2021)	AI and big data for SDGs in South Asian cities	Urban Sustainability	Focus on South Asia limits global generalizability
[9]	Marengo (2024)	Emerging trends in AI-driven IoT data analysis & privacy	IoT / AI / Privacy	Pre-print; limited peer review at time of writing
[10]	Rashid & Kausik (2024)	Comprehensive overview of AI industrial applications	Cross-industry AI	Breadth limits depth; WSN-specific analysis limited
[11]	Trigka & Dritsas (2025)	WSN fundamentals, applications, and future trends	WSN Survey	Taxonomy-focused; limited empirical performance comparison
[12]	Bhatia et al. (2022)	MANET-based control system with AODV routing	Networked Control / WSN	Single routing protocol focus; AI integration not explored

9. Future Research Directions

Based on the synthesis of the reviewed literature, the following priority areas are identified for future research in AI-IoT-WSN integration:

- Lightweight AI architectures for constrained edge devices: Development of novel model compression and neural architecture search techniques capable of delivering high inference accuracy within the computational and memory constraints of typical sensor node hardware.
- Standardized security benchmarking: Establishment of rigorous, publicly available benchmarks for evaluating the security of AI-enhanced IoT-WSN deployments, enabling objective comparison of competing security protocols and intrusion detection approaches.

- Explainable AI (XAI) for WSN decision-making: Integration of interpretability methods into AI-driven WSN management systems, enabling human operators to understand, audit, and override autonomous network decisions in safety-critical applications.
- Privacy-preserving federated learning at scale: Validation of federated learning frameworks in large-scale real-world WSN deployments, addressing challenges of heterogeneous data distributions, communication overhead, and Byzantine fault tolerance.
- Cross-domain interoperability frameworks: Development and adoption of open, vendor-neutral standards for semantic interoperability across heterogeneous IoT-WSN platforms, enabling integration of data from diverse sensor types and organizational domains.
- Ethical AI governance for agricultural and urban WSN: Participatory design processes and regulatory frameworks that ensure AI-WSN technologies are developed and deployed in ways that are equitable, transparent, and aligned with the values of affected communities.
- Energy harvesting and green WSN design: Integration of ambient energy harvesting (solar, vibration, RF) with AI-driven energy management to enable perpetual sensor network operation without battery replacement.
- Quantum-resistant security protocols: Anticipatory development of cryptographic protocols resistant to quantum computing attacks, given the long operational lifetimes of WSN infrastructure.

10. Conclusion

This review has synthesized a diverse body of recent research on the enhancement of Wireless Sensor Networks through the convergence of Artificial Intelligence and the Internet of Things. The evidence reviewed demonstrates clearly that AI-IoT integration substantially extends the capabilities of WSN beyond what is achievable through conventional protocol design, enabling adaptive routing, intelligent anomaly detection, autonomous energy management, and context-aware application services across a wide range of domains.

The reviewed literature collectively establishes that the benefits of AI-IoT-WSN integration are not confined to technical performance metrics. They extend to significant societal impacts—improving agricultural sustainability, advancing smart city infrastructure, enabling industrial automation, and supporting progress toward the Sustainable Development Goals. These impacts are most pronounced when AI-WSN systems are designed with careful attention to the needs, constraints, and rights of the communities they serve.

At the same time, the review has highlighted persistent and emerging challenges that must be addressed to realize the full potential of intelligent sensor networks. Security vulnerabilities, privacy risks, ethical tensions, and interoperability barriers require sustained research attention and coordinated action from the technical, regulatory, and social science communities. The integration of AI into WSN systems does not eliminate these challenges; in some respects, it intensifies them, by increasing the scale, speed, and opacity of network decision-making.

The work of Bhatia et al. [12] on MANET-based networked control with AODV routing represents an important stepping stone in this trajectory, demonstrating the value of adaptive routing in dynamic wireless environments. Future work building on this foundation should explore the systematic integration of AI-based routing intelligence, federated edge learning, and privacy-preserving data management to realize the vision of truly autonomous, secure, and sustainable wireless sensor networks.

In conclusion, the convergence of AI, IoT, and WSN represents one of the most consequential technological developments of the current decade. This review offers a structured map of the current

landscape and a forward-looking agenda for research that is technically rigorous, ethically grounded, and socially beneficial.

References

- [1] M. Han, A. Benson, and J. E. Abon, "Navigating ethics in wireless sensor networks for sustainable agriculture," *Frontiers in Sustainable Food Systems*, vol. 9, 2025, doi: 10.3389/fsufs.2025.1634643.
- [2] M. E. E. Alahi et al., "Integration of IoT-Enabled Technologies and Artificial Intelligence (AI) for Smart City Scenario: Recent Advancements and Future Trends," *Sensors*, vol. 23, no. 11, p. 5206, Jan. 2023. Available: <https://www.mdpi.com/1424-8220/23/11/5206>
- [3] V. J. K. K. Sonti, D. P. Singh, G. Sood, B. Maheshwari, N. Vashisht, and M. S. E, "Security and Privacy Challenges in IoT and Sensor Networks: A Review of Current Solutions," 2025 International Conference on Automation and Computation (AUTOCOM), pp. 685–689, Mar. 2025, doi: <https://doi.org/10.1109/autocom64127.2025.10956191>
- [4] M. S. Basingab et al., "AI-Based Decision Support System Optimizing Wireless Sensor Networks for Consumer Electronics in E-Commerce," *Applied Sciences*, vol. 14, no. 12, pp. 4960–4960, Jun. 2024, doi: <https://doi.org/10.3390/app14124960>.
- [5] X. Pan, Q. Su, L. Wei, and L. Guo, "Research on Ethical Issues and Coping Strategies of Artificial Intelligence Algorithms Recommending News with the Support of Wireless Sensing Technology," *Journal of Sensors*, vol. 2023, p. e8629849, Apr. 2023, doi: <https://doi.org/10.1155/2023/8629849>.
- [6] I. Ahmad et al., "The Challenges of Artificial Intelligence in Wireless Networks for the Internet of Things: Exploring Opportunities for Growth," *IEEE Industrial Electronics Magazine*, vol. 15, no. 1, pp. 16–29, Mar. 2021, doi: <https://doi.org/10.1109/mie.2020.2979272>
- [7] Consegic Business Intelligence, "Asia-Pacific Industrial Wireless Sensor Network Market Insights | U.S. Tariffs, Industry Dynamics, and Strategic Forecast 2025-2032," *Apiary.io*, 2025. Available: <https://asiapacificindustrialwirelessensornetworkmarket.docs.apiary.io>
- [8] Md. Arfanuzzaman, "Harnessing artificial intelligence and big data for SDGs and prosperous urban future in South Asia," *Environmental and Sustainability Indicators*, vol. 11, p. 100127, Sep. 2021, doi: <https://doi.org/10.1016/j.indic.2021.100127>.
- [9] A. Marengo, "Future of AI-Driven IoT: Identifying Emerging Trends in Intelligent Data Analysis and Privacy Protection," Jan. 2024, doi: <https://doi.org/10.20944/preprints202312.2184.v3>
- [10] A. B. Rashid and A. K. Kausik, "AI Revolutionizing Industries Worldwide: a Comprehensive Overview of Its Diverse Applications," *Hybrid Advances*, vol. 7, no. 100277, pp. 100277–100277, 2024, doi: <https://doi.org/10.1016/j.hybadv.2024.100277>
- [11] M. Trigka and E. Dritsas, "Wireless Sensor Networks: From Fundamentals and Applications to Innovations and Future Trends," *IEEE Access*, vol. 13, pp. 96365–96399, 2025, doi: <https://doi.org/10.1109/access.2025.3572328>
- [12] A. Bhatia et al., "Networked control system with MANET communication and AODV routing," *Heliyon*, vol. 8, no. 11, p. e11678, Nov. 2022, doi: <https://doi.org/10.1016/j.heliyon.2022.e11678>.