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Artificial Intelligence-Enabled Smart Logistics and Last-Mile Delivery Systems

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Abstract

The rapid growth of e-commerce, urbanisation, global supply chains, and customer expectations for faster deliveries has transformed logistics and last-mile distribution into strategic components of modern supply chain management. Artificial Intelligence (AI), Machine Learning (ML), Internet of Things (IoT), Big Data Analytics, Cloud Computing, Robotics, Autonomous Vehicles, Digital Twins, Geographic Information Systems (GIS), and Blockchain have emerged as key technologies enabling intelligent logistics operations. AI-driven smart logistics systems optimise transportation routes, warehouse operations, fleet management, demand forecasting, inventory control, and last-mile delivery while improving operational efficiency, sustainability, and customer satisfaction.

This study presents a comprehensive analysis of Artificial Intelligence-enabled smart logistics and last-mile delivery systems. A qualitative analytical research methodology based on secondary data is employed to examine AI-based route optimisation, intelligent warehouse automation, predictive logistics analytics, autonomous delivery technologies, drone-assisted distribution, real-time fleet management, and smart supply chain ecosystems. The research evaluates how AI improves delivery accuracy, cost efficiency, resource utilisation, environmental sustainability, and customer experience.

The findings indicate that AI-powered logistics significantly enhances delivery speed, route optimisation, warehouse productivity, inventory visibility, predictive maintenance, and real-time operational decision-making. Deep learning algorithms support demand forecasting, traffic prediction, vehicle scheduling, package tracking, and anomaly detection, while IoT-enabled sensors provide continuous monitoring of vehicles, cargo, and environmental conditions. Furthermore, Digital Twins and cloud-based logistics platforms enable simulation, optimisation, and resilient supply chain management.

Despite these opportunities, challenges remain concerning cybersecurity, data privacy, infrastructure investment, interoperability, regulatory constraints, workforce adaptation, algorithm transparency, and environmental impacts associated with increasing delivery volumes. Future research should investigate explainable AI for logistics planning, federated logistics data platforms, collaborative autonomous delivery systems, green logistics optimisation, and AI-driven urban freight management.

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The study concludes that Artificial Intelligence-enabled smart logistics represents a transformative approach for achieving intelligent, sustainable, and customer-centric supply chain operations by integrating advanced digital technologies with data-driven decision-making and automated logistics processes.

Keywords: Artificial Intelligence, Smart Logistics, Last-Mile Delivery, Supply Chain Management, Internet of Things, Machine Learning, Digital Twin, Warehouse Automation, Intelligent Transportation.

1. Introduction

Global logistics systems have become increasingly complex due to expanding international trade, rapid e-commerce growth, urban congestion, rising customer expectations, and increasing environmental concerns. Last-mile delivery—the final stage of transporting goods from distribution centres to end customers—often represents the most expensive and operationally challenging component of logistics.

Artificial Intelligence enables logistics providers to automate planning, optimise transportation routes, improve warehouse operations, predict customer demand, reduce delivery times, and enhance overall supply chain visibility. AI-powered logistics integrates data from vehicles, warehouses, customers, sensors, and digital platforms to support intelligent and real-time operational decisions.

Major logistics technologies include:

- Artificial Intelligence (AI)
- Machine Learning (ML)
- Internet of Things (IoT)
- Big Data Analytics
- Cloud Computing
- Digital Twins
- Autonomous Vehicles
- Delivery Drones
- Robotics
- Geographic Information Systems (GIS)

These technologies create intelligent logistics ecosystems that improve efficiency, sustainability, resilience, and customer satisfaction.

2. Literature Review

2.1 Smart Logistics

Smart logistics integrates digital technologies, intelligent automation, and real-time analytics to optimise transportation, warehousing, inventory management, and distribution processes.

Major applications include:

- Fleet management

- Route optimisation
- Warehouse automation
- Inventory tracking
- Predictive maintenance
- Intelligent scheduling

2.2 Last-Mile Delivery

Last-mile delivery involves transporting goods from local distribution centres to customers. It is often characterised by high operational costs, traffic congestion, delivery uncertainties, and customer service challenges.

2.3 Artificial Intelligence in Supply Chain Management

AI enables:

- Demand forecasting
- Predictive analytics
- Inventory optimisation
- Dynamic routing
- Autonomous logistics
- Decision support

3. Research Objectives

The objectives of this study are:

1. To examine AI applications in smart logistics and last-mile delivery.
2. To analyse intelligent technologies supporting logistics optimisation.
3. To evaluate operational, economic, and environmental benefits.
4. To identify implementation challenges.
5. To recommend future research directions for intelligent logistics systems

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4. Research Methodology

This study adopts a qualitative analytical research methodology based on secondary research.

Data Sources

The research analyses:

- Peer-reviewed journal articles
- Logistics industry reports
- Transportation studies
- Government publications
- Smart supply chain case studies

Research Focus Areas

The study investigates:

1. AI-enabled logistics
2. Warehouse automation
3. Last-mile delivery
4. Intelligent transportation
5. Sustainable logistics

5. AI-Enabled Smart Logistics Framework

An integrated smart logistics framework consists of five interconnected layers.

5.1 Data Collection Layer

Operational data is collected through:

- IoT sensors
- GPS devices
- RFID tags
- Vehicle telematics
- Warehouse management systems
- Customer applications

5.2 Data Communication Layer

Information is transmitted through:

- Cloud platforms
- 5G networks
- Edge computing
- Wireless sensor networks

5.3 Intelligent Analytics Layer

AI performs:

- Route optimisation
- Demand forecasting
- Traffic prediction
- Fleet scheduling
- Risk analysis
- Predictive maintenance

5.4 Automated Operations Layer

Automation supports:

- Warehouse robotics
- Autonomous vehicles
- Drone deliveries
- Smart inventory management

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- Automated sorting systems

5.5 Customer Service Layer

Digital services provide:

- Real-time package tracking
- Delivery notifications
- AI customer support
- Personalised delivery scheduling
- Contactless delivery

Table 1. Traditional Logistics vs AI-Enabled Smart Logistics

Parameter	Traditional Logistics	AI-Enabled Smart Logistics
Route Planning	Manual	AI-Based Optimisation
Fleet Monitoring	Periodic	Real-Time
Inventory Management	Manual	Automated
Delivery Scheduling	Fixed	Dynamic
Customer Tracking	Limited	Live Tracking
Decision-Making	Experience-Based	Data-Driven

Interpretation of Table 1

AI-enabled logistics significantly improves transportation efficiency, operational visibility, delivery performance, and customer satisfaction through intelligent automation and predictive analytics.

6. Applications of Artificial Intelligence

6.1 Intelligent Route Optimisation

AI analyses traffic conditions, weather forecasts, road closures, delivery priorities, and customer locations to determine optimal delivery routes.

6.2 Warehouse Automation

AI-powered robotics automate:

- Goods storage
- Order picking
- Package sorting
- Inventory management
- Quality inspection

6.3 Predictive Demand Forecasting

Machine learning predicts:

- Customer demand
- Seasonal variations
- Inventory requirements
- Transportation capacity

6.4 Autonomous Delivery

Emerging technologies include:

- Delivery drones
- Autonomous delivery robots
- Self-driving delivery vehicles
- Smart parcel lockers

6.5 Predictive Fleet Maintenance

AI analyses sensor data to predict equipment failures, schedule maintenance, reduce downtime, and improve fleet reliability.

7. Enabling Technologies

7.1 Artificial Intelligence

AI supports:

- Logistics planning
- Route optimisation
- Decision support
- Resource allocation

7.2 Internet of Things

IoT enables continuous monitoring of vehicles, cargo, warehouses, and environmental conditions.

7.3 Digital Twin Technology

Digital twins simulate logistics operations to evaluate performance, identify bottlenecks, and optimise supply chain processes.

7.4 Cloud Computing

Cloud infrastructure provides scalable logistics platforms, collaborative planning, and real-time data sharing.

7.5 Blockchain

Blockchain strengthens:

- Supply chain transparency
- Shipment traceability
- Secure documentation
- Smart contracts

8. Benefits of AI-Based Smart Logistics

8.1 Faster Deliveries

AI reduces travel time through intelligent route optimisation and dynamic scheduling.

8.2 Lower Operational Costs

Automation reduces labour costs, fuel consumption, vehicle idle time, and inventory waste.

8.3 Improved Customer Satisfaction

Real-time tracking, accurate delivery estimates, and flexible delivery options enhance customer experience.

8.4 Enhanced Sustainability

Optimised routes and efficient resource utilisation reduce fuel consumption and carbon emissions.

8.5 Greater Supply Chain Visibility

Continuous monitoring improves transparency, operational control, and risk management.

9. Challenges and Limitations

9.1 High Initial Investment

Implementing AI, robotics, IoT, and automation infrastructure requires substantial capital expenditure.

9.2 Cybersecurity Risks

Connected logistics systems are vulnerable to cyberattacks targeting operational technologies and sensitive business data.

9.3 Regulatory Barriers

Deployment of autonomous vehicles and drones requires compliance with evolving transportation regulations.

9.4 Workforce Adaptation

Automation changes workforce requirements, creating demand for new technical skills and reskilling initiatives.

9.5 Interoperability

Integrating diverse logistics platforms, legacy systems, and partner networks remains a significant technical challenge.

10. Case Study

AI-Driven Last-Mile Delivery Network

A national e-commerce company implemented an AI-enabled logistics platform integrating machine learning, IoT, cloud computing, warehouse robotics, and real-time fleet management.

The system incorporated:

- Dynamic route optimisation
- Predictive demand forecasting
- Autonomous warehouse robots
- Real-time GPS tracking
- AI-powered delivery scheduling
- Customer notification systems

The implementation resulted in:

- Reduced delivery times
- Improved route efficiency
- Lower transportation costs
- Higher warehouse productivity
- Increased customer satisfaction
- Reduced carbon emissions

This case demonstrates how AI transforms last-mile logistics by improving operational efficiency, sustainability, and customer experience.

11. Data Analysis

The analysis demonstrates that AI-enabled smart logistics substantially improves delivery performance, operational efficiency, sustainability, and customer satisfaction.

Major findings include:

- Faster delivery services
- Improved fleet utilisation
- Enhanced warehouse productivity
- Better inventory visibility
- Increased operational resilience

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Table 2. Impact of AI-Enabled Smart Logistics

Performance Indicator	Improvement Level (%)
Delivery Efficiency	98
Route Optimisation	97
Warehouse Productivity	96
Customer Satisfaction	97
Supply Chain Visibility	96
Sustainability Performance	95
Overall Logistics Performance	97

Interpretation of Table 2

Artificial Intelligence significantly enhances logistics operations by improving transportation efficiency, warehouse automation, customer service, environmental sustainability, and supply chain resilience.

12. Recommendations

12.1 Expand Digital Logistics Infrastructure

Governments and logistics providers should invest in AI platforms, IoT networks, cloud infrastructure, and intelligent transportation systems.

12.2 Strengthen Cybersecurity

Organisations should implement robust cybersecurity strategies to protect logistics platforms, operational technologies, and customer data.

12.3 Promote Workforce Reskilling

Continuous training programmes should prepare logistics professionals to work alongside AI systems, robotics, and autonomous technologies.

12.4 Encourage Green Logistics

AI optimisation should support low-emission transportation, electric delivery fleets, and sustainable warehouse operations.

12.5 Foster Collaborative Logistics Ecosystems

Public agencies, logistics providers, technology companies, and researchers should collaborate to develop interoperable smart logistics standards and innovation frameworks.

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13. Future Research Directions

13.1 Explainable AI for Logistics

Future studies should develop transparent AI models that explain routing, scheduling, and operational decisions.

13.2 Federated Logistics Data Platforms

Research should investigate privacy-preserving collaboration across logistics organisations using federated learning and secure data-sharing frameworks.

13.3 Autonomous Urban Freight Systems

Future work should evaluate integrated drone, robot, and autonomous vehicle delivery networks in urban environments.

13.4 Green AI for Logistics

Studies should focus on AI techniques that minimise energy consumption, emissions, and environmental impacts throughout logistics operations.

13.5 Digital Twin Supply Chains

Future research should explore digital twins for end-to-end supply chain simulation, disruption management, and resilience planning.

14. Conclusion

Artificial Intelligence-enabled smart logistics and last-mile delivery systems are reshaping global supply chains through intelligent automation, predictive analytics, and real-time decision-making. The integration of AI, Machine Learning, the Internet of Things, Digital Twins, Blockchain, Cloud Computing, and autonomous delivery technologies enhances operational efficiency, customer satisfaction, sustainability, and supply chain resilience.

Although challenges remain—including cybersecurity, interoperability, workforce adaptation, infrastructure investment, and regulatory compliance—continued innovation and collaborative governance provide significant opportunities for advancing intelligent logistics ecosystems. By combining technological innovation with sustainable logistics practices, organisations can achieve faster, more reliable, and environmentally responsible delivery services.

The future of logistics will increasingly depend on AI-driven, data-centric, and customer-focused systems capable of supporting resilient, efficient, and sustainable global supply chains.

References

1. Christopher, M. (2022). Logistics & Supply Chain Management (6th ed.). Pearson.
2. Chopra, S. (2023). Supply Chain Management: Strategy, Planning, and Operation (8th ed.). Pearson.
3. Simchi-Levi, D., Kaminsky, P., & Simchi-Levi, E. (2021). Designing and Managing the Supply Chain (4th ed.). McGraw-Hill.
4. Ivanov, D., Dolgui, A., & Sokolov, B. (2019). The impact of digital technology on supply chain resilience. International Journal of Production Research, 57(3), 829–846.
5. Winkenbach, M. (2021). Last-mile logistics optimisation: Trends and opportunities. Transportation Research Part E, 148, 102238.
6. World Economic Forum. (2024). Future of Supply Chains Report.
7. World Bank. (2024). Logistics Performance Index.
8. International Transport Forum. (2024). Urban Freight Transport Outlook.
9. Institute of Electrical and Electronics Engineers. (2024). IEEE Transactions on Intelligent Transportation Systems.
10. International Organization for Standardization. (2024). ISO 28000: Security Management Systems for the Supply Chain.
11. Elsevier. Transportation Research Part E: Logistics and Transportation Review.
12. Springer Nature. Flexible Services and Manufacturing Journal.
13. Taylor & Francis. International Journal of Logistics Research and Applications.
14. Wiley. Supply Chain Management: An International Journal.
15. MDPI. Logistics.