

Transforming  
Intelligent  
Manufacturing-Based  
Urban Management  
through IoT and Big  
Data Analytics

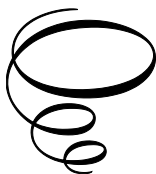


# Transforming Intelligent Manufacturing-Based Urban Management through IoT and Big Data Analytics

Edited by

Sushobhan Majumdar  
and Moharana Choudhury

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Transforming Intelligent Manufacturing-Based Urban Management  
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The editors of this book dedicate the book to the  
Great Almighty and their family members



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## FOREWORD

The Fourth Industrial Revolution has ushered in an era where digital technologies such as the Internet of Things (IoT) and Big Data Analytics are reshaping the world as we know it. Among the most profound transformations is the convergence of intelligent manufacturing systems with urban management practices—a fusion that holds the potential to redefine how our cities operate, grow, and thrive. It is in this crucial context that the book *“Transforming Intelligent Manufacturing-Based Urban Management through IoT and Big Data Analytics”* finds its timely relevance and significance.



This volume presents a compelling narrative and analytical framework for understanding how data-driven manufacturing ecosystems can influence, and indeed enhance, the planning and governance of modern urban spaces. In today's smart cities, the distinction between industrial operations and civic infrastructure is becoming increasingly blurred. Factories communicate with city utilities, sensors monitor traffic, energy, and waste systems in real-time, and data flows are continuously analyzed to improve both productivity and quality of life.

The authors have thoughtfully curated a collection of insights, case studies, and practical methodologies that illustrate how IoT-enabled intelligent manufacturing is not only revolutionizing production processes but also offering innovative solutions to urban challenges, from energy efficiency and resource optimization to responsive governance and sustainable mobility. What makes this work particularly valuable is its interdisciplinary approach. Bridging the domains of industrial engineering, urban planning, information systems, and data science, this book serves as a foundational text for academics, practitioners, policymakers, and technologists who are seeking to navigate and lead in this new digital-urban paradigm. In an age of increasing complexity and rapid urbanization, the integration of smart manufacturing with urban systems represents a strategic pathway to build more resilient, efficient, and intelligent cities. This book not only captures that vision but also equips its readers with the knowledge and tools necessary to turn it into reality. I

wholeheartedly commend the authors for their forward-thinking contributions and encourage all readers to explore the ideas within these pages with curiosity, ambition, and a readiness to innovate.

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## PREFACE

The global convergence of urbanization and technological advancement is reshaping the very foundation of how cities function, and industries operate. In this era of rapid transformation, the integration of **Intelligent Manufacturing, Internet of Things (IoT), and Big Data Analytics** is no longer a conceptual vision—it is an operational imperative. This edited volume, *Transforming Intelligent Manufacturing-Based Urban Management through IoT and Big Data Analytics*, explores how these disruptive technologies drive innovation at the intersection of smart industry and smart cities.

The chapters in this volume bring together interdisciplinary insights from engineering, urban planning, data science, policy, and economics to illuminate how IoT-enabled manufacturing processes influence urban infrastructure, resource management, and governance models. The contributors critically examine emerging systems that are breaking down silos between industrial production and urban services, including energy grids, transportation systems, environmental monitoring, and workforce development. These transformations, powered by real-time data and intelligent decision-making systems, offer the potential for more sustainable, adaptive, and equitable urban-industrial ecosystems.

This book is intended for researchers, practitioners, policymakers, and graduate students engaged in smart manufacturing, urban innovation, and digital transformation. By bridging theory and practice, it seeks to provide both conceptual frameworks and applied perspectives to guide the future of integrated urban-industrial development.

We are grateful to the contributors whose expertise and diverse perspectives have shaped this volume. Their work reflects the collaborative spirit and forward-thinking vision necessary to navigate the challenges and opportunities of the Fourth Industrial Revolution. It is our hope that this book will serve as a valuable resource for those committed to building smarter, more connected, and more sustainable cities through the power of intelligent manufacturing and data-driven technologies.

**Sushobhan Majumdar  
Moharana Choudhury**

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This edited book is prepared as one of the components of the book series on “**Intelligent Manufacturing, Internet of Things (IoT), and Big Data Analytics**,” special thanks are due to the parenting organizations of the editors for providing the basic facilities as and when needed. The support in the form of literature and advice from state pollution control board officials has been gratefully received since the very beginning of this book project. Indirect yet quality vital support has been obtained from the “Voice of Environment” (A Scientific and Environmental Research Organization) to complete the task.

We, the editors, extend our thanks to all the contributing authors across the world in this book, our colleagues, research supervisors, collaborators, and scholars for their direct or indirect help, and to the team at Cambridge Scholar Publishing UK for their enthusiasm and commitment to publishing this book in various ways.

Finally, we would like to acknowledge the vital contributions of all the esteemed reviewers and researchers worldwide involved in this book volume. This includes those whose written words may not appear in this book but whose ideas, experiences, and inputs into discussion parts are fully reflected in the printed work.

The book reflects our vision and collaborates with many brilliant minds and kind hearts who believe in this book volume.

## LIST OF ABBREVIATIONS

ICT	Information and Communication Technology
POM	Production and Operations Management
IoT	Internet of Things
AI	Artificial Intelligence
CPS	Cyber-Physical Systems
LSFMS	Large-Scale Foundation Models
ML	Machine Learning
IT	Information Technology
GDPR	General Data Protection Regulation
SEZ	Special Economic Zones
MQTT	Message Queuing Telemetry Transport
COAP	Constrained Application Protocol
CRM	Customer Relationship Management
ERP	Enterprise Resource Planning
LPWAN	Low-Power Wide-Area Networks
AR	Augmented Reality
VR	Virtual Reality
DDOS	Distributed Denial-Of-Service
IDPS	Intrusion Detection and Prevention Systems
PII	Personally Identifiable Information
GDPR	General Data Protection Regulation
GIS	Geographic Information Systems
DISSCO	Distributed System of Scientific Collections
WAN	Wide Area Network
LAN	Local Area Network
V2I	Vehicle-To-Infrastructure
IoV	Internet of Vehicles
CNN	Convolutional Neural Networks
LSTM	Long Short-Term Memory
ITS	Intelligent Transportation Systems
URLLC	Ultra-Reliable and Low-Latency Communication
HVAC	Heating, Ventilation, and Air Conditioning
DER	Distributed Energy Resources
VPP	Virtual Power Plants
CPP	Critical Peak Pricing

TOU	Time-Of-Use
BMS	Building Management Systems
EVs	Electric vehicles
V2G	Vehicle-To-Grid
MRT	Mass Rapid Transit
O&M	Operation and Maintenance
SDG	Sustainable Development Goals
MIMOS	Malaysian Institute of Microelectronic Systems
AIoT	Artificial Intelligence of Things
TTC	Toronto Transit Commission
GTFS	General Transit Feed Specification
BRT	Bus Rapid Transit
LDT	Local Digital Twins
ICCs	Integrated Command and Control Centres
LTA	Land Transport Authority
NAS	National Appointment System
TULIP	Technology for Urban Liveability Program
DSS	Decision Support System
NLP	Natural Language Processing
PdM	Predictive Maintenance
RCM	Reliability-Centered Maintenance
SVM	Support Vector Machines
SAE	Stacked Auto Encoder
URA	Urban Redevelopment Authority
AVL	Automated Vehicle Location
TSP	Transit Signal Priority
AMI	Advanced Metering Infrastructure
BEMS	Building Energy Management System

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# INTRODUCTION

The Fourth Industrial Revolution is redefining the boundaries between the digital, physical, and biological worlds, with **Intelligent Manufacturing**, **the Internet of Things (IoT)**, and **Big Data Analytics** at its core. These technologies are transforming how goods are produced and how cities are planned, managed, and experienced. As industrial systems become increasingly data-driven and interconnected, a new paradigm is emerging—one in which manufacturing and urban management are no longer separate domains but are deeply integrated through digital platforms, sensor networks, and intelligent automation.

This edited volume, *Transforming Intelligent Manufacturing-Based Urban Management through IoT and Big Data Analytics*, examines this integration from multiple disciplinary and practical perspectives. It explores how smart manufacturing systems—equipped with real-time data processing, autonomous decision-making, and cyber-physical capabilities— influence and reshape urban infrastructure, logistics, resource optimization, and environmental sustainability. Conversely, it investigates how cities evolve to accommodate and support advanced manufacturing ecosystems through adaptive policy frameworks, smart infrastructure, and data governance mechanisms.

The book is structured to provide a holistic understanding of the evolving relationship between industry and urban systems. Early chapters establish foundational concepts, including the role of IoT and data analytics in intelligent manufacturing. Subsequent sections delve into the impacts on urban energy systems, transportation, waste management, and workforce transformation. The volume also addresses pressing challenges such as cybersecurity, technological disparities, ethical considerations, and the need for inclusive policy development.

By presenting theoretical insights and real-world applications, this book aims to inform researchers, urban planners, technologists, and policymakers working at the intersection of manufacturing and urban innovation. It emphasizes the need for cross-sector collaboration and system-level thinking to realize the full potential of smart technologies in creating resilient, efficient, and inclusive urban-industrial environments.

In an era where cities are becoming more like living organisms— responsive, data-rich, and increasingly automated—this volume offers a

timely exploration of how intelligent manufacturing can serve as both a catalyst and a partner in sustainable urban transformation.

## **SECTION 1**

# **BUILDING THE FUTURE: FUNDAMENTALS OF INTELLIGENT MANUFACTURING AND URBAN MANAGEMENT**

# CHAPTER 1

## INNOVATIVE SYNERGY: EXPLORING INTELLIGENT MANUFACTURING'S IMPACT ON URBAN MANAGEMENT AND MANUFACTURING PROCESSES

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### **Abstract**

As cities increasingly embrace digital transformation, intelligent manufacturing has emerged as a pivotal force driving innovation across both industrial production and urban management. This chapter examines the intersection of smart manufacturing technologies—such as artificial intelligence, industrial IoT, robotics, and advanced data analytics—with urban systems and infrastructure. It explores how the integration of these technologies not only enhances manufacturing efficiency and flexibility but also contributes to more responsive, sustainable urban governance. From optimizing energy consumption and reducing emissions to supporting smart logistics and workforce development, intelligent manufacturing plays a dual role in reshaping industrial ecosystems and urban environments. The chapter also addresses policy considerations, workforce implications, and the need for public-private collaboration to fully realize these synergies. By highlighting real-world case studies and future trends, this chapter illustrates the transformative potential of intelligent manufacturing in creating smarter, more adaptive cities.

**Keywords:** Intelligent Manufacturing, Urban Management, Industry 4.0, Smart Cities, Digital Transformation

## 1.1 Introduction

Intelligent manufacturing, propelled by AI, Iot, and big data, profoundly influences urban management and manufacturing operations. It improves urban management through optimised resource allocation, enhanced logistics, and increased infrastructure efficiency—manufacturing results in optimised production, decreased costs, and improved product quality.

Overview of intelligent manufacturing: The use and utilisation of next-generation information and communication technologies (ICTs) enhances the interconnectivity and transparency of intelligent manufacturing (IM) systems, hence transforming information interaction and work processes. This necessitates a reevaluation of work management practices. These modifications necessitate the following attributes for IM production and operations management (POM): integration, flexibility, networking, autonomous and collaborative decision-making, learning-oriented operations management, self-optimisation and adaptability, and proactive decision-making (Zhou et al., 2022).

### 1.1.1 Effects on Urban Management:

**Enhanced Resource Allocation:** Intelligent manufacturing principles can be utilised in urban transportation and waste management, optimising resource distribution through real-time data and predictive analytics.

**Enhanced Logistics:** IoT and AI can optimise urban logistics by refining delivery routes, warehouse management, and inventory control.

**Augmented Infrastructure:** Intelligent manufacturing can monitor and sustain urban infrastructure, averting malfunctions and guaranteeing operational efficiency.

**Sustainable Urban Development:** Intelligent manufacturing may enhance sustainable urban development by optimising energy usage, minimising waste, and fostering environmentally friendly activities.

**Influence on Manufacturing Procedures:**

**Enhanced Production:** Real-time data and analytics empower manufacturers to refine production processes, minimise downtime, and augment efficiency.

**Cost Reduction:** Intelligent manufacturing can decrease expenses by optimising resource utilisation, minimising waste, and enhancing energy efficiency.

**Improved Product Quality:** Data-driven insights facilitate the monitoring and regulation of manufacturing quality, guaranteeing uniformity and superior products.

**Enhanced Flexibility and Agility:** Intelligent manufacturing facilitates superior flexibility and agility in adapting to fluctuating market demands, permitting swift prototyping and customization.

**Principal Technologies:** The Internet of Things (IoT) facilitates instantaneous data acquisition and interconnectivity among objects and systems.

**Artificial Intelligence (AI):** Delivers data-driven insights and facilitates automation.

**Big Data Analytics:** Facilitates the examination of extensive datasets to discern trends and patterns.

**Cloud Computing:** Offers scalable storage and computational resources for data analysis and applications.

**Cyber-Physical Systems (CPS):** Merges physical and digital systems for cohesive interaction and regulation.

Intelligent manufacturing fundamentally alters the management of cities and the production of goods, resulting in enhanced efficiency, sustainability, and innovation in urban settings and manufacturing methodologies.

### **1.1.2 Emergence of smart cities and urban digital transformation**

The notion of a smart city has emerged as a feasible resolution to the challenges posed by urbanisation. Digital technologies, including the Internet of Things, artificial intelligence, big data, and geospatial technology, are intricately linked to the notion of a smart city. Cities seek to enhance their efficiency and services with contemporary digital technologies. Cities actively promote contemporary digital technology to facilitate digitalisation and the development of data-driven innovations and a knowledge economy. This study presents a foundation for clever city design. The framework examines a smart city through four dimensions: strategy, technology, governance, and stakeholders. The framework includes sub-dimensions to enhance innovative city programs' governance and sustainability (Hämäläinen et al., 2019). Creating innovative and sustainable cities is a gradual process, not achievable overnight. This chapter emphasises essential terminology and frameworks pertinent to the subject while acknowledging the significant contributions made by worldwide standards development organisations in this field. Urban stakeholders progressively strive to incorporate new and emerging technologies (AI, IoT, blockchain, machine learning) into their innovative city initiatives. Nonetheless, when integrating these many technologies into a single ecosystem, it is crucial to recognise their comprehensive interactions concerning urban operations.



**Fig 1-1** A glimpse of urban planning and transformation near the river bank area with environmental and transportation perspectives (Photo by Moharana Choudhury)

### 1.1.3 Decade of Research on Intelligent Manufacturing, Processes, and Urban Management: A Bibliometric Analysis (2015–2024)

A bibliometric analysis was conducted using the Scopus database to explore the dynamic research landscape related to intelligent manufacturing, manufacturing processes, and urban management. The search query was TITLE-ABS-KEY (intelligent AND manufacturing OR manufacturing AND processes OR urban AND management) AND PUBYEAR > 2014 AND PUBYEAR < 2025, focusing on publications from 2015 to 2024. This timeframe was selected to highlight recent advancements and evolving scholarly interests over the past decade. The analysis offers insights into publication growth trends, regional research activity, and institutional contributions within these interrelated domains. Visualizations—such as Figures 1, 2, and 3—depict annual publication outputs, the geographic distribution of research, and the most prolific organizations driving innovation and knowledge in this area.

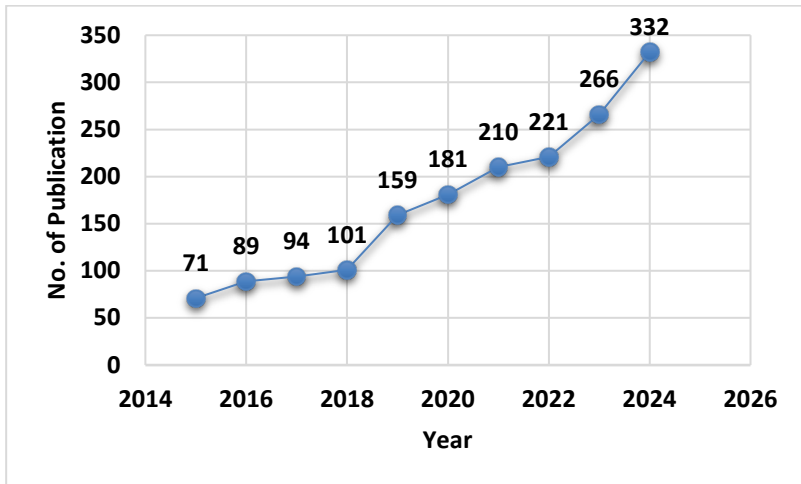


Fig 1-2 Year-wise Distributions of Publications (2015–2024)

Between 2015 and 2024, 1,724 research documents were published in the area of interest. The field demonstrated a gradual increase in output in the early years, beginning with 71 publications in 2015 and rising modestly to 89 in 2016 and 94 in 2017 (Fig 1.2). Growth became more pronounced in subsequent years, with 101 publications in 2018 and 159 in 2019. The