
Contents

Preface	xvii
Abhishek KUMAR, Priya BATTA, S. Oswalt MANOJ, Dhaya CHINNATHAMBI and Srivel RAVI	
Chapter 1. Blockchain and Water Supply Chain: Opportunities, Challenges and Innovations	1
Priya BATTA, Vikas WASSON and Soumen SARDAR	
1.1. Introduction	1
1.1.1. Challenges of blockchain in the water supply chain	3
1.1.2. Opportunities of blockchain in the water supply chain	4
1.1.3. Blockchain innovations in the water supply chain	6
1.2. Literature review.	7
1.2.1. 2018: basic pilot projects (permissioned blockchain)	7
1.2.2. 2019: early adoption with small-scale sensor integration	8
1.2.3. 2020: broader pilot integration of IoT and blockchain.	8
1.2.4. 2021: advanced consensus protocols for scalability	8
1.2.5. 2022: hybrid blockchain solutions (public/private networks).	8
1.2.6. 2023: widespread adoption and automated compliance via smart contracts	9
1.2.7. 2024: AI-driven analytics on blockchain data	9
1.3. Methodology	11
1.4. Results	13
1.5. Conclusion	14
1.6. References	15

Chapter 2. Blockchain-enabled Water Supply Chain Management: A Decentralized Approach to Sustainability and Efficiency	19
N. KOUSIKA, Ramani P., Ramya V. and M. AKILANDEESWARI	
2.1. A synopsis of the blockchain system.	19
2.2. Introduction to blockchain for water resource management	21
2.3. Opportunities in the management of water resources.	23
2.4. IoT and blockchain: risks and opportunities.	23
2.5. Literature survey.	24
2.6. Water supply chain optimization	27
2.6.1. Proposed working model.	28
2.7. Blockchain framework for water resource management	29
2.8. Conclusion	30
2.9. References	31
 Chapter 3. AI Blockchain Synergy Enhancing Predictive Water Management for Efficient Supply Chain Operations	35
Kavitha K., Thiagarajan A., Jeyakarthic M. and Suganya R	
3.1. Background.	35
3.2. Role of AI in predictive analytics and resource optimization	38
3.2.1. Blockchain technology for data security, transparency and decentralization	40
3.2.2. Existing approaches and limitations.	41
3.3. AI-blockchain-optimized water supply chain algorithm	42
3.3.1. AI-driven predictive water demand estimation.	43
3.3.2. Dynamic resource allocation using RL	43
3.3.3. Blockchain-based data integrity and smart contracts	44
3.3.4. Predictive maintenance using anomaly detection	44
3.3.5. AI-driven predictive maintenance and analytics	44
3.3.6. Blockchain-based data security and decentralized access	45
3.4. Hypothesis: AI-blockchain synergy for enhancing predictive water management in supply chain operations	46
3.4.1. Predictive water demand estimation using AI	46
3.4.2. AI-based predictive maintenance for infrastructure reliability	47
3.4.3. Blockchain-based data security and trust in water transactions	47
3.4.4. Efficiency gain hypothesis (performance improvement)	48
3.5. Study: AI-blockchain synergy enhancing predictive water management for efficient supply chain operations.	48
3.5.1. Case study context: smart water management in city X	48
3.5.2. Implementation of AI-blockchain system.	49
3.5.3. Results and impact	49

3.6. Predictive water management using AI	50
3.6.1. ML models for water usage prediction	50
3.6.2. Anomaly detection and system bias alerts	51
3.6.3. Dynamic time window-based resource distribution	52
3.6.4. Case study: AI-based prediction accuracy and efficiency gains	52
3.7. Experimental evaluation and results	53
3.8. Page layout	55
3.9. Challenges and future directions	55
3.9.1. Technical and implementation challenges	55
3.9.2. Scalability concerns in AI and blockchain integration.	56
3.9.3. Potential enhancements and future research directions	56
3.9.4. Policy and regulatory considerations	56
3.10. Summary of key findings of chapter	57
3.10.1. Impact of AI-blockchain synergy on water supply chain efficiency.	57
3.10.2. Final thoughts on sustainable water resource management	57
3.11. References	58

Chapter 4. Unleashing Blockchain's Potential: Transforming Water Supply Chains with Transparency, Traceability and Decentralized Efficiency

61

K. THIAGARAJAN, Benazir F. BEGUM, G. SUPRAJA, K. SELVI,
Dileep PULUGU and P. MALATHI

4.1. Introduction	61
4.1.1. Background	61
4.1.2. Objectives	63
4.1.3. Scope.	64
4.2. Literature review.	65
4.3. Methodology	67
4.3.1. Phase 1: integration of data and IoT deployment.	67
4.3.2. Phase 2: smart contract design.	69
4.3.3. Phase 3: stakeholder consensus and governance	70
4.3.4. Phase 4: traceability and transparency layer	72
4.3.5. Implementation and simulation	73
4.4. Results	73
4.4.1. Transparency outcomes	74
4.4.2. Traceability results	75
4.4.3. Efficiency outcomes	77
4.4.4. Fraud-reducing outcomes	77
4.4.5. Discussion of the results	79
4.5. Conclusion	79
4.6. References	80

Chapter 5. From Source to Tap: Enhancing Traceability and Provenance Tracking in Water Supply Chains with Blockchain Technology	83
N. ELAMATHI, Vaishnavi R., Annie T.A., Dileep PULUGU, P. REVATHY and B. Prameela RANI	
5.1. Introduction	84
5.1.1. Background	84
5.1.2. Objectives	85
5.1.3. Scope.	86
5.2. Literature review.	86
5.3. Methodology	88
5.3.1. Phase 1: capturing provenance data	88
5.3.2. Phase 2: blockchain network installation	89
5.3.3. Phase 3: traceability workflow automation	91
5.3.4. Phase 4: integration of stakeholder access	92
5.4. Results	93
5.4.1. Traceability time	94
5.4.2. Provenance accuracy	96
5.4.3. Stakeholder engagement	97
5.4.4. Discussion	99
5.5. Conclusion	99
5.6. References	100
 Chapter 6. Blockchain-Powered Route Tracking: Enhancing Data Integrity and Fraud Prevention	103
R. DHANALAKSHMI, J. RAJESHWAR, Syeda Ambareen RANA, Harika B., P. REVATHY and Poongulali E.	
6.1. Introduction	104
6.1.1. Issues with traditional water route monitoring systems	104
6.1.2. Blockchain guarantees the integrity of water path tracking data	104
6.1.3. Anti-fraud through blockchain-based water route tracking	105
6.1.4. Real-time visibility and transparency of the water supply chain	105
6.1.5. Blockchain tracking of water routes and future supply chains	105
6.2. Literature review.	106
6.3. Methodology	108
6.3.1. System architecture and blockchain choice.	108
6.3.2. Data collection and integration with IoT devices	109
6.3.3. Smart contracts for automated compliance and fraud detection.	110
6.3.4. Data security and immutable ledger for fraud prevention	111
6.3.5. Integration with existing logistics systems and stakeholder collaboration	112

6.3.6. Performance optimization and scalability considerations	112
6.3.7. Real-world implementation and case studies	113
6.3.8. Future trends and evolving innovations	113
6.4. Results	113
6.4.1. Data integrity improvement in route tracking	113
6.4.2. Fraud prevention effectiveness	114
6.4.3. Security enhancements in blockchain-based route tracking	115
6.4.4. Adoption rate of blockchain-powered tracking in logistics	116
6.5. Conclusion	117
6.6. References	118

Chapter 7. Securing Route Data with Blockchain:

A Decentralized Approach to Fraud Detection 121

SEETARAM, S. GOPIKHA, Vaishnavi R., Dileep PULUGU,

J. PRAVEEN KUMAR and B. Prameela RANI

7.1. Introduction	122
7.1.1. Water route data security and fraud threat introduction	122
7.1.2. Blockchain as a decentralized solution to water route data security	122
7.1.3. Use of smart contracts for fraud detection	123
7.1.4. Enabling transparency and trust for water route-based transactions	123
7.1.5. Advantages of blockchain-based water route data protection	123
7.1.6. Blockchain water route future and security challenges	124
7.2. Literature review.	124
7.2.1. Blockchain supply chain and logistics	124
7.2.2. Blockchain and smart contracts for route safety	125
7.2.3. Machine learning for anomaly detection in blockchain systems	125
7.2.4. Cybersecurity and data privacy in blockchain-based route systems	125
7.2.5. Blockchain application in compliance reporting and regulatory compliance	126
7.2.6. Scalability and performance enhancement of blockchain	126
7.2.7. Blockchain applications for agriculture and IoT-based logistics	127
7.2.8. Summary of literature review	127
7.3. Methodology	127
7.3.1. Data procurement and preprocessing	128
7.3.2. Blockchain integration and decentralized storage	129
7.3.3. Smart contracts for fraud detection and anomaly detection	131
7.3.4. Implementation of real-time monitoring and auditing	132
7.4. Results	133
7.4.1. Fraud detection accuracy using blockchain and smart contracts	133
7.4.2. Blockchain-based transaction validation efficiency	134
7.4.3. Compliance reporting success rate	135
7.4.4. Improvements in system performance through blockchain	136

7.5. Conclusion	137
7.6. References	138
Chapter 8. Blockchain-powered DeFi: Transforming Water Project Financing for a Sustainable Future	141
R. SHYAMALA, D. PRABAKARAN, C. DHAYA, Chaarumathi S., Uma PERUMAL and V. Senthil KUMARAN	
8.1. Introduction	142
8.1.1. Limitations of traditional financing models	144
8.2. Water project financing methods – an overview	146
8.2.1. Existing DeFi models.	146
8.2.2. Existing DeFi models – advantages	148
8.2.3. DeFi model – challenges	149
8.3. Blockchain and DeFi – an understanding	150
8.4. Water project financing – DeFi-based solution	153
8.5. Case studies and real-time implementation	155
8.5.1. Challenges and future prospects	156
8.6. Challenges and performance discussion	157
8.6.1. Regulatory and legal challenges	158
8.6.2. Security risks and vulnerabilities	158
8.6.3. Scalability and transaction throughput	159
8.6.4. Liquidity constraints and market volatility	159
8.6.5. Integration with traditional financial systems	159
8.6.6. Performance evaluation and efficiency metrics	160
8.7. Conclusion	163
8.8. References	164
Chapter 9. Empowering Sustainable Water Management: Blockchain Innovations for Achieving the SDGs	167
M.K. VIDHYALAKSHMI, R. ANITHA, Aswathy K. CHERIAN, B. YAMINI, N. NITHIYANANDAM and Sundaravadivazhagn BALASUBARAMANIAN	
9.1. Introduction: the urgency of sustainable water management.	167
9.2. The global water crisis: challenges and opportunities	169
9.2.1. The role of technology in achieving Sustainable Development Goal 6.	169
9.2.2. The role of blockchain in building a resilient water future	170
9.3. Blockchain applications in water quality monitoring.	170
9.3.1. Real-time water quality tracking with blockchain	171
9.4. Case studies: blockchain-based water quality initiatives	171
9.5. Ensuring data integrity and public trust in water safety	172
9.5.1. Enhancing water access and distribution through blockchain.	172
9.5.2. Decentralized water resource management	172

9.5.3. Peer-to-peer water trading and pricing transparency	173
9.5.4. Reducing corruption and inefficiencies in water distribution	173
9.6. Blockchain for water financing and investment	173
9.7. Smart contracts for water infrastructure funding	174
9.8. Crowdsourcing and decentralized finance in water projects	175
9.9. Microtransactions to work and fair prices for water	176
9.10. Case studies: real-world blockchain solutions for water sustainability	176
9.11. Regulatory challenges and compliance in blockchain implementations: a scrutiny	177
9.12. Public–private partnerships in the adoption of blockchain	178
9.13. Ethical considerations and data privacy in water management	179
9.14. The future of blockchain in sustainable water management	180
9.14.1. Role of blockchain in sustainable water management	181
9.14.2. IoT as the backbone of data collection	181
9.14.3. AI for advanced analytics	181
9.14.4. Challenges and future directions	182
9.14.5. Measuring success and scaling efforts	182
9.14.6. Vision for smarter and sustainable water solutions	183
9.15. Collaborative multi-stakeholder efforts	183
9.16. Conclusion	184
9.17. References	184
Chapter 10. Role of Blockchain in Transforming the Water Supply Chain	187
Gagandeep KAUR, Soumen SARDAR, Pardeep Singh TIWANA and Neha SHARMA	
10.1. Introduction	187
10.1.1. Overview of water supply chain management	189
10.2. Key challenges in the water supply chain	190
10.3. Related studies	194
10.4. Role of digital transformations in WSCM	196
10.4.1. Cloud-based water management	197
10.4.2. Blockchain for water transactions	197
10.4.3. Digital twin technology	197
10.4.4. Consumer engagement and smart invoicing	198
10.4.5. Sustainability and strategy agreement	198
10.5. BT adoption in water supply chain	198
10.6. Blockchain applications in water supply chain	200
10.7. Global examples of blockchain in water management	202
10.8. Future prospects and conclusion	203
10.9. References	204

Chapter 11. IoT-based Systems for Water Management Systems: A Comprehensive Bibliometric Analysis	209
Gagandeep SINGH, Manmeet KAUR and ARUNDHATI	
11.1. Introduction	209
11.2. Literature review	212
11.3. Methodology	216
11.4. Results	217
11.5. Limitations	223
11.6. Conclusion	224
11.7. References	226
 Chapter 12. Adaptive Water Supply Chain Management: A Hybrid Algorithm for Predictive Maintenance and Leak Detection	229
Suganya R. and Prakash B.	
12.1. Introduction	229
12.2. Background and related work	230
12.2.1. Current approaches in water supply management	230
12.2.2. Role of AI, blockchain and quantum computing in water systems	231
12.2.3. Limitations of existing predictive maintenance and leak detection techniques	232
12.2.4. Review of recent advancements in smart water networks	233
12.3. The ABQWSO algorithms: a hybrid approach	233
12.3.1. Blockchain integration for secure data sharing	234
12.3.2. AI-based predictive maintenance	234
12.3.3. Quantum computing for water flow optimization	235
12.4. System architecture and implementation	236
12.4.1. Framework design	236
12.4.2. Computational model and algorithm workflow	238
12.4.3. Security and privacy considerations	240
12.5. Experimental results and performance evaluation	240
12.5.1. Simulation and testing environment	240
12.5.2. Evaluation metrics	241
12.5.3. Comparison with existing techniques	242
12.6. Conclusion	245
12.6.1. Summary of key findings	245
12.6.2. Future enhancements for ABQWSO	245
12.7. References	246

Chapter 13. Supporting Sustainable Development Goals 249

G. USHA, Vinoth N.A.S., THAMIZHAMUTHU, A. ANBARASI and S.P. MANIRAJ

13.1. Introduction	249
13.2. Role of blockchain in supporting SDGs	250
13.2.1. Enhancing transparency and accountability	250
13.2.2. Ensuring water quality and safety	251
13.3. Improving water resource management	253
13.4. Reducing corruption and fraud	254
13.5. Enabling decentralized water governance	256
13.6. Case studies and real-world applications	258
13.6.1. Blockchain-based water quality monitoring in India	258
13.6.2. Peer-to-peer water trading in Australia	260
13.6.3. Smart water management in Africa	263
13.7. Challenges and future prospects	266
13.7.1. Scalability and integration issues.	266
13.7.2. Data privacy and security concerns	266
13.7.3. Policy and regulatory frameworks	267
13.8. Conclusion	268
13.9. References	269

Chapter 14. Fuzzy System for Environmental Monitoring 271

Ashwini S., Dhwarithaa R., R. Nithya PARANTHAMAN,

Preethiya T., Ramya G. and Abinaya G.

14.1. Fuzzy logic-based environmental monitoring and control	271
14.2. Fundamentals of fuzzy systems in environmental monitoring	275
14.3. Case studies and applications of fuzzy systems	280
14.3.1. Air quality monitoring	280
14.3.2. Water pollution assessment.	285
14.3.3. Climate change analysis	288
14.4. Hybrid fuzzy-AI models for environmental decision-making	290
14.4.1. Machine learning for fuzzy rule optimization.	291
14.4.2. Deep learning for enhanced environmental prediction	291
14.4.3. Advantages of hybrid fuzzy-AI systems.	292
14.4.4. Practical applications of fuzzy-AI models.	292
14.5. Challenges and solutions in implementing fuzzy systems	294
14.5.1. Computational complexity	294
14.5.2. Parameter tuning issues	295
14.5.3. Interpretability of fuzzy rules.	295
14.5.4. Scalability and real-time deployment	295
14.6. Future research directions	295

14.7. Conclusion	296
14.8. References	297
Chapter 15. Importance of the Water Supply Chain	299
MAMTA	
15.1. Introduction	299
15.1.1. Concept of water supply chain	299
15.1.2. Significance in modern infrastructure	300
15.2. Core components of the water supply chain	301
15.2.1. Source water systems	303
15.2.2. Distribution networks	304
15.2.3. End-user delivery systems	305
15.3. Critical aspects of the water supply chain	306
15.3.1. Infrastructure requirements	306
15.3.2. Quality control measures	307
15.3.3. Supply chain security	307
15.4. Key challenges in water management systems	308
15.4.1. Infrastructure maintenance	308
15.4.2. Resource management	309
15.4.3. Quality assurance	310
15.5. Technology integration in water supply chain management	311
15.5.1. Current technological solutions	311
15.5.2. Blockchain potential in the water supply chain	312
15.5.3. Future technology roadmap	313
15.6. Recommendations and future direction	314
15.6.1. Best practices	314
15.6.2. Implementation strategies	315
15.6.3. Future opportunities	315
15.7. References	316
Chapter 16. The Significance of Data Privacy in Water Supply Chain and Blockchain Technology	319
Krishna PRASAD KARANI and Anup PATNAIK	
16.1. Introduction	319
16.2. Objectives	320
16.3. Scope of study	321
16.4. Literature review	321
16.4.1. Conceptual background	323
16.5. Research methodology	324
16.5.1. Secondary data	324
16.5.2. Primary data	325

16.6. Analysis	325
16.6.1. Analysis of secondary data	326
16.6.2. Analysis of primary data	327
16.6.3. Missing data imputation analysis.	329
16.6.4. Blockchain implementation analysis.	330
16.6.5. Expert interview analysis	333
16.6.6. Discussion	333
16.7. Conclusion	335
16.8. References	336

Chapter 17. Quenching Tomorrow: Innovations and Trends in Sustainable Water Management 339

Anushka BHATNAGAR, Pooja MAHAJAN and Gaganpreet KAUR

17.1. Introduction	339
17.2. Innovative technologies in water management	340
17.2.1. Smart water grids	342
17.2.2. Internet of Things (IoT).	342
17.2.3. Advanced water treatment technologies.	343
17.2.4. Using big data	344
17.2.5. Intelligent systems and learning algorithms.	345
17.3. Blockchain technology in water supply	346
17.3.1. Blockchain framework	347
17.4. Sustainable water management practices.	350
17.4.1. Wastewater management	350
17.4.2. Green and eco-friendly nanotechnology.	351
17.4.3. Graywater recycling systems	353
17.5. Integrated water resource management (IWRM)	355
17.5.1. Solar energy	355
17.5.2. Wind energy	355
17.5.3. Hydroelectric power.	355
17.5.4. Biomass energy	355
17.5.5. Geothermal energy	356
17.6. Emerging research and future directions in water management	356
17.7. Conclusion	357
17.8. References	357

Chapter 18. Integrating Blockchain Technology in Water Supply Chain Management: Challenges and Opportunities 365

Mukul GARG, Mehak MALHOTRA, Pooja MAHAJAN and Gaganpreet KAUR

18.1. Introduction	365
18.2. Blockchain technology in water supply chain	367
18.2.1. Fundamentals of blockchain technology	367

18.2.2. Applications in water supply chains	369
18.2.3. Efficiency and accountability of blockchain	371
18.3. Challenges in blockchain adoption in water supply chains	373
18.3.1. Technological barriers	374
18.3.2. Economic and financial challenges	375
18.3.3. Regulatory and compliance issues	376
18.3.4. Infrastructural limitations	376
18.3.5. Organizational and governance constraints	377
18.3.6. Environmental concerns	379
18.3.7. Data security issues	379
18.4. Case studies and global perspectives	380
18.5. Methods for overcoming challenges	382
18.5.1. Advanced technological developments	383
18.5.2. Economic models	384
18.5.3. Supportive regulatory environment	384
18.5.4. Enhancing infrastructure	385
18.5.5. Enhanced governance frameworks	385
18.5.6. Models for sustainability adoption	386
18.5.7. Data governance frameworks	386
18.5.8. Promoting stakeholder awareness	387
18.6. Conclusion and implications	387
18.7. References	388
List of Authors	393
Index.	401