Computer Science

E-ISSN No : 2581-6195 | Volume : 9 | Special Issue | Aug 2026

AI-ENABLED DECISION SUPPORT SYSTEMS FOR SUSTAINABLEDEVELOPMENT:ACOMPREHENSIVEREVIEW OF OPPORTUNITIES, APPLICATIONS, CHALLENGES, AND FUTURE RESEARCH DIRECTIONS

Madhuri Gupta[1], Aadarsh Joshi[2]

ABSTRACT

Artificial Intelligence (AI) has emerged as a transformative technology for enhancing decision-making across diverse sectors including healthcare, agriculture, transportation, manufacturing, environmental management, education, and governance. AI-enabled Decision Support Systems (AI-DSS) integrate machine learning, deep learning, optimization techniques, big data analytics, Internet of Things (IoT), and cloud computing to assist policymakers, industries, and organizations in making accurate, efficient, and sustainable decisions. Sustainable development requires balancing economic growth, environmental protection, and social equity while addressing complex global challenges such as climate change, resource depletion, food security, and public health. Traditional Decision Support Systems often fail to process massive real-time heterogeneous datasets and dynamic environmental conditions, whereas AI-enabled DSS provide predictive intelligence, adaptive learning, and automated reasoning capabilities.

This review comprehensively examines recent advancements in AI-enabled DSS for sustainable development by synthesizing literature published between 2020 and 2026. The review discusses enabling technologies, application domains, benefits, implementation challenges, ethical concerns, explainable AI, governance issues, and future research directions. It also identifies research gaps and proposes an integrated conceptual framework for next-generation sustainable AI decision systems.

KEYWORDS: Artificial Intelligence, Decision Support System, Sustainable Development, Machine Learning, Deep Learning, Explainable AI, Smart Cities, IoT, Optimization

[1] Assistant Professor, Department of Computer Science, Mind Power University, Bhimtal
[2] Assistant Professor, Computer Science and Engineering, Mind Power University,Bhimtal

How to Cite:
Madhuri Gupta & Aadarsh Joshi (2026), AI-Enabled Decision Support Systems for Sustainable Development: A Comprehensive Review of Opportunities, Applications, Challenges, and Future Research Directions, International Educational Journal of Science & Engineering (IEJSE),Vol: 9, Special Issue, Aug 2026 38-42

Research Paper

1. INTRODUCTION

Sustainable development has become one of the foremost priorities for governments, industries, and international organizations. The United Nations Sustainable Development Goals (SDGs) provide a global roadmap for achieving economic prosperity while protecting environmental resources and promoting social well-being. Achieving these goals requires timely, data-driven, and intelligent decision-making.

Decision Support Systems (DSS) have historically assisted managers by organizing information, performing analysis, and supporting policy formulation. However, conventional DSS face limitations in handling:

- Big data
- Real-time information
- Uncertain environments
- Multi-objective optimization
- Dynamic decision environments

Artificial Intelligence has significantly transformed DSS by introducing autonomous learning, predictive analytics, optimization, and reasoning capabilities.

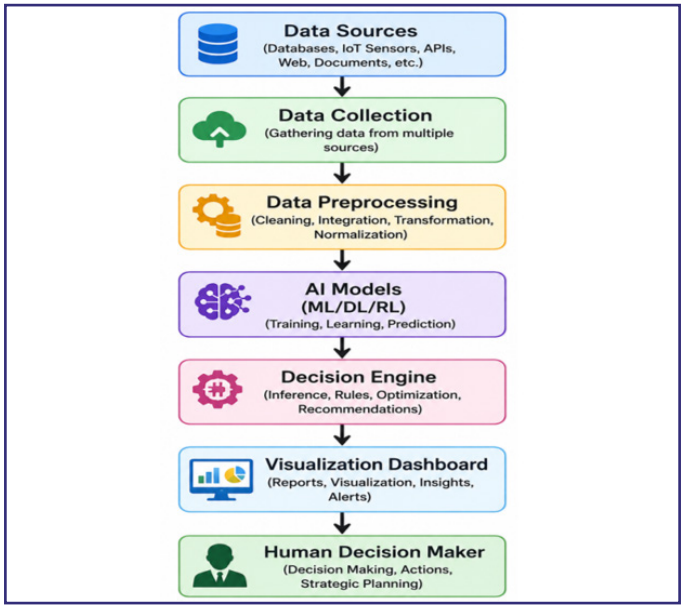
AI-enabled DSS combine:

- Machine Learning
- Deep Learning
- Expert Systems
- Knowledge Graphs
- Reinforcement Learning
- Natural Language Processing
- Computer Vision
- IoT
- Cloud Computing
- Edge Computing

These technologies enable sustainable decision-making in real time while improving accuracy and reducing operational costs.

2. BACKGROUND OF AI-ENABLED DECISION SUPPORT SYSTEMS

A Decision Support System is a computer-based information system that assists decision-makers in solving semi-structured and unstructured problems.



Traditional DSS typically include:

- Database Management System
- Model Management System
- User Interface
- Knowledge Base

AI enhances DSS by introducing intelligent capabilities including:

- Learning from historical data
- Pattern recognition
- Predictive modeling
- Automated recommendations
- Continuous improvement

Modern AI-DSS architecture integrates:

3. AI TECHNOLOGIES USED IN DECISION SUPPORT SYSTEMS

3.1 Machine Learning

Machine learning enables prediction based on historical datasets.

Applications include:

- Demand forecasting
- Crop prediction
- Energy consumption estimation
- Disease prediction
- Financial risk analysis

Popular algorithms:

- Random Forest
- Decision Tree
- Support Vector Machine
- XGBoost
- KNN

3.2 Deep Learning

Deep learning improves image analysis, speech recognition, and complex pattern detection.
Common models include:

- CNN
- RNN
- LSTM
- Transformers

Applications:

- Medical diagnosis
- Remote sensing
- Climate forecasting

3.3 Reinforcement Learning

RL helps optimize sequential decision-making.
Applications:

- Smart traffic systems
- Energy optimization
- Smart grid management
- Autonomous transportation

3.4 Natural Language Processing

NLP assists policymakers through:

- Document analysis
- Policy recommendation
- Chatbots
- Public opinion analysis

3.5 Explainable AI

Explainability improves trust by making AI decisions interpretable.

Popular methods:

- SHAP
- LIME
- Attention Visualization

4. APPLICATIONS OF AI-DSS IN SUSTAINABLE DEVELOPMENT

4.1 Smart Agriculture

Applications include:

- Precision farming
- Irrigation optimization
- Crop disease detection
- Fertilizer recommendation

Benefits:

- Water conservation
- Increased crop yield
- Reduced pesticide usage

4.2 Healthcare

AI-DSS support:

- Disease diagnosis
- Drug recommendation
- Epidemic prediction
- Resource allocation

Benefits:

- Early diagnosis
- Reduced mortality
- Efficient healthcare delivery

4.3 Smart Cities

AI-DSS improve:

- Traffic management
- Waste collection
- Water distribution
- Public safety

4.4 Environmental Sustainability

Applications include:

- Air quality prediction
- Forest fire detection
- Climate monitoring
- Flood prediction
- Disaster management

4.5 Energy Systems

AI supports:

- Renewable energy forecasting
- Smart grids
- Demand-side management
- Battery optimization

4.6 Transportation

Applications include:

- Route optimization
- Traffic prediction
- Electric vehicle charging optimization
- Intelligent logistics

4.7 Education

AI-DSS provide:

- Personalized learning
- Student performance prediction
- Curriculum planning
- Academic analytics

5. OPPORTUNITIES

Major opportunities include:

- Real-time decision making
- Big data analytics
- Improved policy planning
- Smart governance
- Resource optimization
- Cost reduction
- Enhanced transparency
- Climate resilience
- Sustainable resource allocation
- Digital transformation

6. CHALLENGES

Despite numerous benefits, AI-enabled DSS face several challenges.

Technical Challenges

- Poor data quality
- Missing data

- Model bias
- Computational complexity
- Scalability

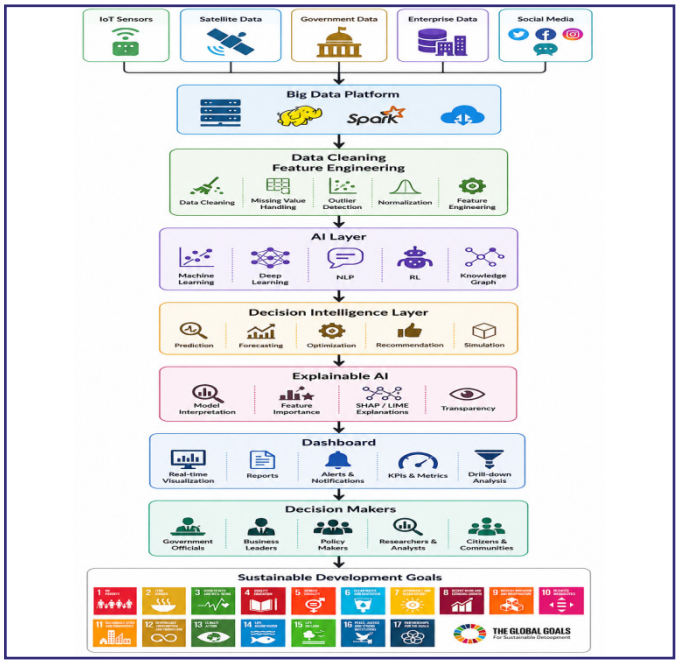
Ethical Challenges
- Privacy
- Fairness
- Accountability
- Transparency

Organizational Challenges
- Lack of AI expertise
- High implementation cost
- User resistance
- Infrastructure limitations

7. RESEARCH GAP

The literature reveals several research gaps:
- Limited integration across multiple SDGs
- Lack of explainable AI models
- Few AI-DSS for developing countries
- Limited real-time adaptive DSS
- Insufficient interdisciplinary research
- Lack of benchmark datasets
- Weak sustainability performance evaluation

8. FUTURE RESEARCH DIRECTIONS



Future AI-DSS should focus on:

Explainable AI
Transparent decision-making.

Federated Learning
Privacy-preserving AI.

Digital Twins
Simulation-based sustainable planning.

Green AI
Energy-efficient AI models.

Human-Centered AI
Collaborative human-AI decision-making.

Multi-Agent Systems
Distributed intelligent decision support.

Quantum AI
Optimization of large-scale sustainability problems.

Edge AI
Real-time decentralized decision support.

9. PROPOSED CONCEPTUAL FRAMEWORK

10. CONCLUSION

Artificial Intelligence is transforming Decision Support Systems into intelligent, adaptive, and predictive platforms capable of addressing the increasingly complex challenges of sustainable development. AI-enabled DSS significantly enhance decision quality through advanced analytics, automation, optimization, and real-time insights. Their applications span agriculture, healthcare, energy, transportation, environmental monitoring, education, manufacturing, and smart cities, directly contributing to the achievement of multiple Sustainable Development Goals.

However, widespread adoption remains constrained by challenges related to data quality, algorithmic bias, privacy, explainability, interoperability, infrastructure, and governance. Addressing these issues requires interdisciplinary collaboration, standardized evaluation frameworks, robust ethical guidelines, and greater emphasis on transparent and human-centered AI. Future research should prioritize Explainable AI, Federated Learning, Digital Twins, Green AI, Edge Intelligence, and trustworthy AI ecosystems to develop scalable, sustainable, and socially responsible decision support solutions.

SUGGESTED RECENT REFERENCES (2020–2026)

1. Russell, S., &Norvig, P. (2021). Artificial Intelligence: A Modern Approach (4th ed.).
2. United Nations. (2023). The Sustainable Development Goals Report.
3. OECD. (2024). AI Principles and Responsible AI.
4. European Commission. (2024). Ethics Guidelines for Trustworthy AI.
5. Goodfellow, I., Bengio, Y., &Courville, A. Deep Learning.
6. Sutton, R. S., &Barto, A. G. Reinforcement Learning: An Introduction.
7. Lundberg, S. M., & Lee, S. I. (2017). A Unified Approach to Interpreting Model Predictions.
8. Ribeiro, M. T., Singh, S., &Guestrin, C. (2016). Why Should I Trust You? Explaining the Predictions of Any Classifier.
9. Kusiak, A. (2024). Artificial Intelligence in Smart Manufacturing.
10. Recent review articles (2022–2026) on AI-enabled DSS, Explainable AI, Smart Cities, Sustainable AI, and AI for SDGs from journals such as Expert Systems with Applications, Decision Support Systems, Applied Soft Computing, Journal of Cleaner Production, Sustainable Cities and Society, and IEEE Access.