Chapter 1
An Adaptive Geo-Intelligent System Integrating AI and IoT for Sustainable Smart Manufacturing

Duggirala Aravind
http://orcid.org/0009-0005-4362-7684
ASET College of Science and Technology, India

N. V. Suresh
http://orcid.org/0000-0002-0393-6037
ASET College of Science and Technology, India

R. N. Ravikumar
http://orcid.org/0009-0009-3705-1681
Marwadi University, India

E. Eswara Reddy
http://orcid.org/0000-0003-0387-1437
CMR University, India

Vanathi GopiKrishna
http://orcid.org/0009-0009-0667-6507
AVICHI College of Arts and Science, India

Kasukurthi Aravind
http://orcid.org/0009-0007-3768-3422
ASET College of Science and Technology, India

ABSTRACT

The chapter introduces an adaptive geo-intelligent system that combines Geographic Information Systems (GIS), Artificial Intelligence (AI), and Internet of Things (IoT) in order to aid the spatially enabled decision-making in the current manufacturing context. The framework uses sensor data based on location, predictive analytics, and geo-AI models to track the movements of energy, emissions, materials and equipment performance. Through the generation of persistent spatial-temporal intelligence, it enhances the minimization of waste, mitigation of risks, supply chain

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responsiveness, and compliance with the environment. The chapter also outlines the principles of architecture design, implementation journey, and application use cases of sustainable manufacturing operations. Future research topics lead to the opportunities of digital twins, autonomous optimisation, the creation of scalable geo-intelligent networks of Industry 5.0 ecosystems.

1. INTRODUCTION

The manufacturing systems are quickly changing towards data oriented, sustainable and spatially conscious systems. With the transition to sophisticated digital technologies in the industries, geo-intelligence in real-time is a key to better utilisation of resources, minimised emissions, and increased resilience of operations. The framework of this chapter includes a combination of GIS-AI-IoT to allow a sustained spatial-temporal sustainability intelligence of the next generation manufacturing.

1.1 Need for Real-Time, Spatially Enabled Intelligence in Manufacturing

Current smart manufacturing systems are in high dynamic spatial-temporal conditions where energy dynamic, material mobility, dispersion of emissions, and machine conditions are continuously changing throughout geographically dispersed sites. This real time spatial variability cannot be measured by traditional monitoring architectures that utilize isolated sensors or periodic reporting to capture spatial variations (Safari Bazargani et al., 2021). In the process of development of India towards Industry 5.0, manufacturing systems will need geo-intelligent infrastructures that can combine IoT-enabled field data together with Geographic Information Systems (GIS) to produce spatially intelligent analytics (Kamilaris & Ostermann, 2018). This type of intelligence allows the factories to analyze spatial mobility of inventory, geofenced equipment behaviour, and location-specific sustainability results.

Live geo-AI models continue to provide a higher predictive potential of equipment breakdowns, potential congestion and environmental variances. The manufacturers cannot operationalise the precision decision-making, minimise the carbon intensity, or optimises the resource cycles without spatial-temporal intelligence. Thus, a coherent, real-time geo-intelligent layer will be invaluable in resilient operations, sustainable manufacturing optimisation and nationally scalable industrial digitalisation in accordance with the advanced-manufacturing vision of India (Rozanec et al., 2022; San Emeterio de la Parte et al., 2023).

Geomatics Applications in Rooftop Solar PV Potential Mapping: A Case Study at The Papua New Guinea University of Technology

Jeremiah Renagi, Tingneyuc Sekacand Sujoy Kumar Jana (2027). *GIS Applications for Enhancing Sustainable Operational Performance of Manufacturing Industries (pp. 135-160).*

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