


Chapter 8


Integration of Machine Learning and AI With Geospatial Analysis

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ABSTRACT

The aim of the chapter is to provide a more comprehensive vision of how machine learning (ML) and artificial intelligence (AI) technologies can be used together with geospatial analysis to help solve modern environmental problems. This study shows that spatial data, remote sensing, and powerful computational techniques can be used to transform environmental monitoring, prediction, and decision-making processes using the power of ML/AI-enhanced geospatial tools. Demonstrated via hands-on case studies based on wind speed data of Lagos, Nigeria, it was shown how several ML algorithms, such as Random Forest (RF), Naïve Bayes (NB), XGBoost (XGB), Linear Regression (LR) and Neural Networks (NN), can be utilised to recognise and predict patterns in the environment. The models were validated using Root Mean Square Errors (RMSE) and Mean Absolute Error (MAE).

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INTRODUCTION

The rapid growth of coastal megacities in West Africa presents unprecedented challenges to environmental management and sustainable development. Several challenges can be observed by examining the case of Lagos, Nigeria's economic capital and one of the world's most rapidly developing urban centres, with a population of over 17 million people that grows by 3.5% per year (World Population Review). Local atmospheric dynamics, particularly wind patterns, have become increasingly important in renewable energy planning, air quality measures, urban climate control, and climate change adaptation measures (Oyewole & Aro, 2018).

Conventional methods in meteorological analysis may be part of the solution, though they usually fail to recognise the detailed interplay between urban morphology, coastal effects, and the atmosphere that act to influence wind circulation patterns in tropical coastal metropolises (Odekanle *et al*, 2022). The combination of Geographic Information Systems (GIS), remote sensing, machine learning (ML), and artificial intelligence (AI) presents new opportunities to enhance various capabilities for understanding environmental systems and inform evidence-based decisions that promote sustainable urban development. AI and ML have taken centre stage in geospatial analysis to handle this complexity (Dristas & Trigka, 2025).

Remote sensing has entered the big data era thanks to the quick development of sensor technologies, lower satellite deployment costs, and broad IoT adoption. Massive volumes, high acquisition frequencies, format heterogeneity, and high dimensionality set modern geospatial data apart from traditional datasets. These traits present substantial storage, processing, and integration challenges in addition to opening doors for deeper insights. Deep learning algorithms, including convolutional neural networks (CNNs) to analyse images and recurrent neural networks (RNNs/LSTMs) to learn time-varying dynamics, have increased the capacity to identify more complex spatial and temporal behaviours. In addition, there are new developments in cloud computing (e.g., Google Earth Engine, AWS, Azure) and edge computing, which have democratised access to high-performance analytics, making it possible to run near real-time applications like disaster response and precision agriculture.

Despite these advances, several challenges remain. Concerns such as data quality, interoperability, algorithm bias, model interpretability, and ethical considerations must be addressed to achieve reliable and socially responsible results (Siddique, 2024). Furthermore, successful implementation involves interdisciplinary co-operation, which involves data science, spatial analysis, and domain-specific expertise. New opportunities have already arisen to provide secure, scalable, and real-time geospatial intelligence through emerging technologies, such as deep learning, Internet of Things (IoT) sensors, and blockchain, which are likely to promote this integration further. Geospatial Artificial Intelligence (GeoAI) is a relatively recent paradigm that has

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