Land Utilisation Monitoring in Ports using GeoAI

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Introduction

Primary Research Question: *How can AI-driven geospatial analysis optimise land utilisation in port facilities?*

Goal	Optimise land utilisation using AI-driven geospatial analysis
Problem	Traditional methods are labour-intensive
Solution	Implement GeoAI for automated feature extraction and analysis
Potential	Future collaborations and scalable applications

Operational Context and Problem Framing

Land Constraints	Yard Diversity	Operational Insight
Limited space in ports	*RoRo ≠ LoLo ≠ Passenger*	*Dwell times, delivery data*

Commercial ports operate under tight spatial constraints, where every square metre of land must serve a purpose. As trade volumes grow, so does the pressure to optimise land use. Yet, some traditional monitoring methods are slow, resource-heavy, and often outdated.

This project explores how GeoAI can support port operators by offering a **scalable, automated approach** to understanding **land use patterns over time**. Rather than focusing on isolated incidents like a temporary backlog or a quiet day, the goal is to assess whether areas are **consistently under- or over-utilised**.

By identifying long-term trends in land usage, especially in commercial shipping ports where operational complexity is high and space is limited, we aim to uncover opportunities to **repurpose under-used areas** and improve overall efficiency and throughput.

This research aims to lay the groundwork for a more responsive and evidence-based approach to managing port infrastructure.

Methodology and Analysis

1. Data Preparation
- Acquire and pre-process satellite and aerial imagery.
- Assess data quality and relevance for model training.

2. GeoAI Model Training
- Train models to detect vehicles, containers, and HGVs.
- Curate datasets from annotated imagery.

3. Object Detection
- Apply models to classify features in the study area.
- Detect objects in satellite and aerial imagery.

4. Spatial Outputs
- Overlay detections with building footprints and static features.
- Generate heatmaps to visualize land use patterns.

GeoAI Model Training

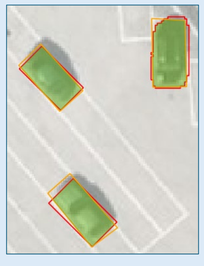
Platform:
GeoAI (Python-based spatial AI framework)

Model: *Mask R-CNN* (Used for detecting and segmenting cars and containers.)

Annotation:
- Created manually in QGIS and saved as GEOJSON.
- Each object (e.g. container, car) was outlined to train the model.

Training Summary:
- [Containers] 36 tiles → 28 train / 8 validate
- [Cars] 6 tiles → 4 train / 2 validate
- *Time:* ~1.5 hrs each
- *Epochs:* 75 (Containers), 100 (Cars)
- Augmentation: RGB only

Performance:
IoU Scores
Containers: 89%
Cars: 84%



Modelled Input > Output



Applications and Real-World Benefits

This approach enables port operators to identify **underutilised land**, **optimise yard layouts**, and **support strategic redevelopment** - such as converting idle car parks into storage zones. It reduces reliance on manual inspections, offering scalable, repeatable insights across commercial ports, inland terminals, and airports.

With integration of **operational data**, it can inform decisions, improve throughput, and **enhance collaboration** between port authorities and tenants - ultimately driving more efficient, sustainable land use.

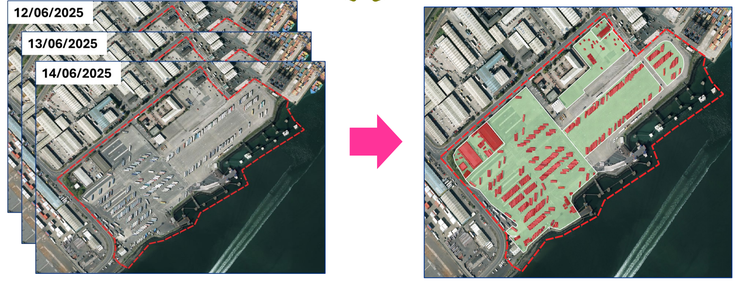


Conclusion and Next Steps

This proof of concept shows GeoAI's potential to identify underutilised land in ports. Future work could integrate **multi-date aerial imagery** to track usage over time.

Incorporating **delivery schedules**, **dwell times**, and **yard-specific definitions** will refine insights. With improved resolution and operational context, this approach can be scaled across a range of port types and logistical hubs.

Daily Image Capture → GeoAI → **Composite Activity Metrics**



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