Predicting Land Use/Land Cover Dynamics for Urban Planning and Flood-Risk Mitigation in Lagos State Using the MOLUSCE Cellular Automata

BY

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Background of the Study

- Land cover describes physical surface features, while land use refers to human activities on land.
- LULC is influenced by natural processes and human activities such as urbanisation and population growth.
- Rapid urban expansion in Lagos has led to land reclamation and increased stress on ecosystems.
- These changes have significant environmental and socio-economic impacts.
- Understanding LULC dynamics is essential for effective planning, environmental management, and sustainable development.

Statement of the Problem

- **Unchecked Urbanization & Rising Flood Risks:** Rapid urban expansion and land reclamation are actively degrading coastal ecosystems and accelerating flood vulnerabilities.
- **The Challenge of Tracking Rapid Transformations:** The sheer pace of Lagos's sprawl makes it incredibly difficult to maintain the consistent, up-to-date spatial tracking required for effective planning.
- **Optical Mapping Failures in Tropical Climates:** Persistent tropical clouds severely restrict the visibility and reliability of standard optical satellite mapping.
- **Inadequate Single-Sensor Methodologies:** Existing local studies often rely on single-sensor imagery that fails to fully capture the structural complexity of a highly heterogeneous megacity.
- **Failure to Anticipate Future Growth:** Current LULC research is largely retrospective, lacking the predictive spatial models needed to proactively manage future expansion.

Aim and Objectives

To integrate Sentinel-1 and Sentinel-2 imagery, machine learning classification algorithms, and GIS for land use change evaluation and prediction in Lagos State.



To integrate Sentinel-1 (SAR) and Sentinel-2 (Optical) data.



To evaluate and identify the optimal machine learning classifier.



To quantify and map dominant LULC patterns in Lagos State for selected years



To analyse the spatio-temporal transitions using change detection maps & matrices; and



To simulate and predict future LULC expansion for the year 2028.

Scope of the Study

Thematic (Classes)

1. Built-up Area
2. Vegetation
3. Water Body
4. Bare Land

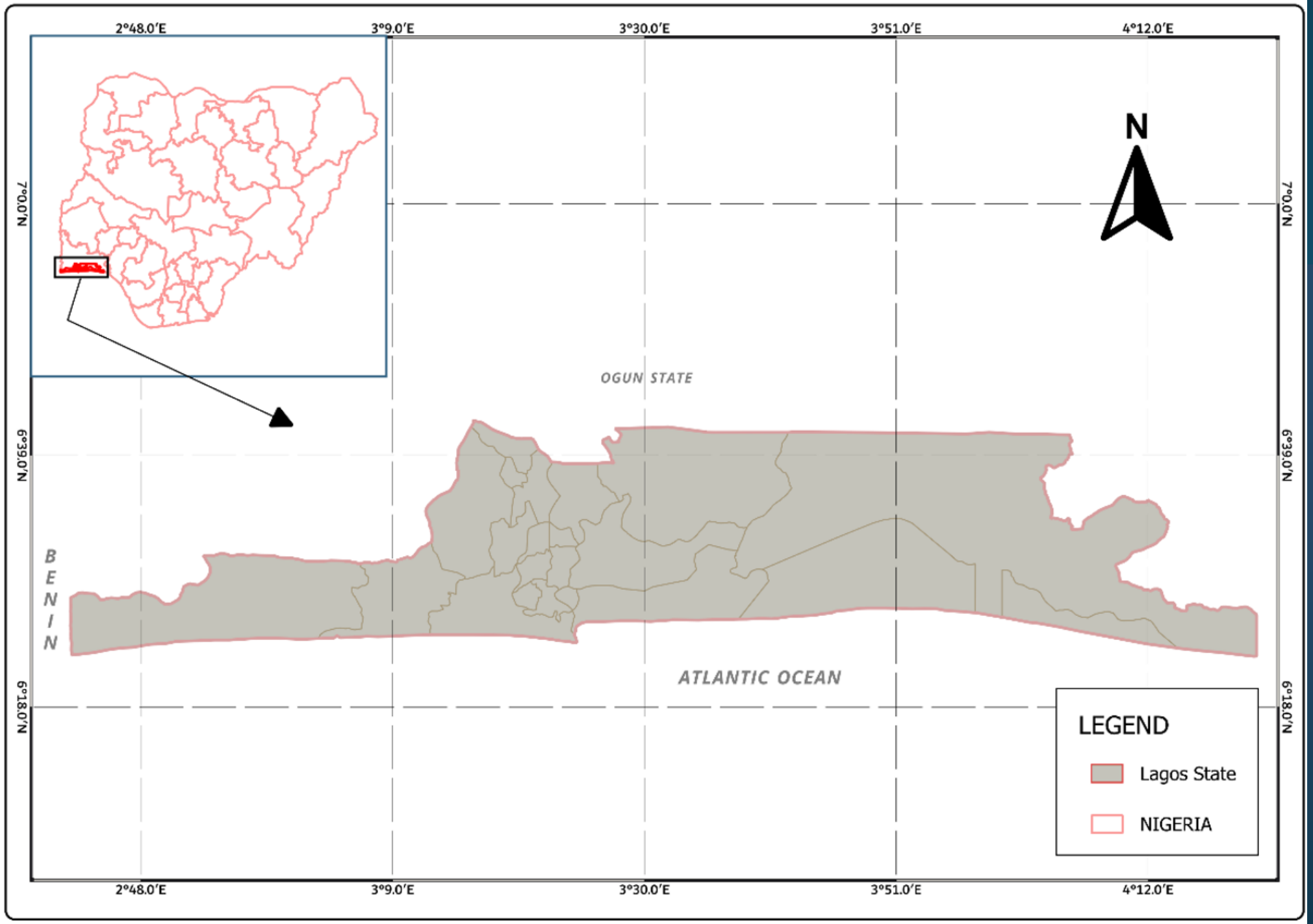
Temporal

1. 2016
2. 2019
3. 2022, and
4. 2025.

Methodological

1. Optical Sentinel-2 imagery
2. Synthetic Aperture Radar (Sentinel-1) data

STUDY AREA



LAGOS STATE
6°35'N, 3°45'E

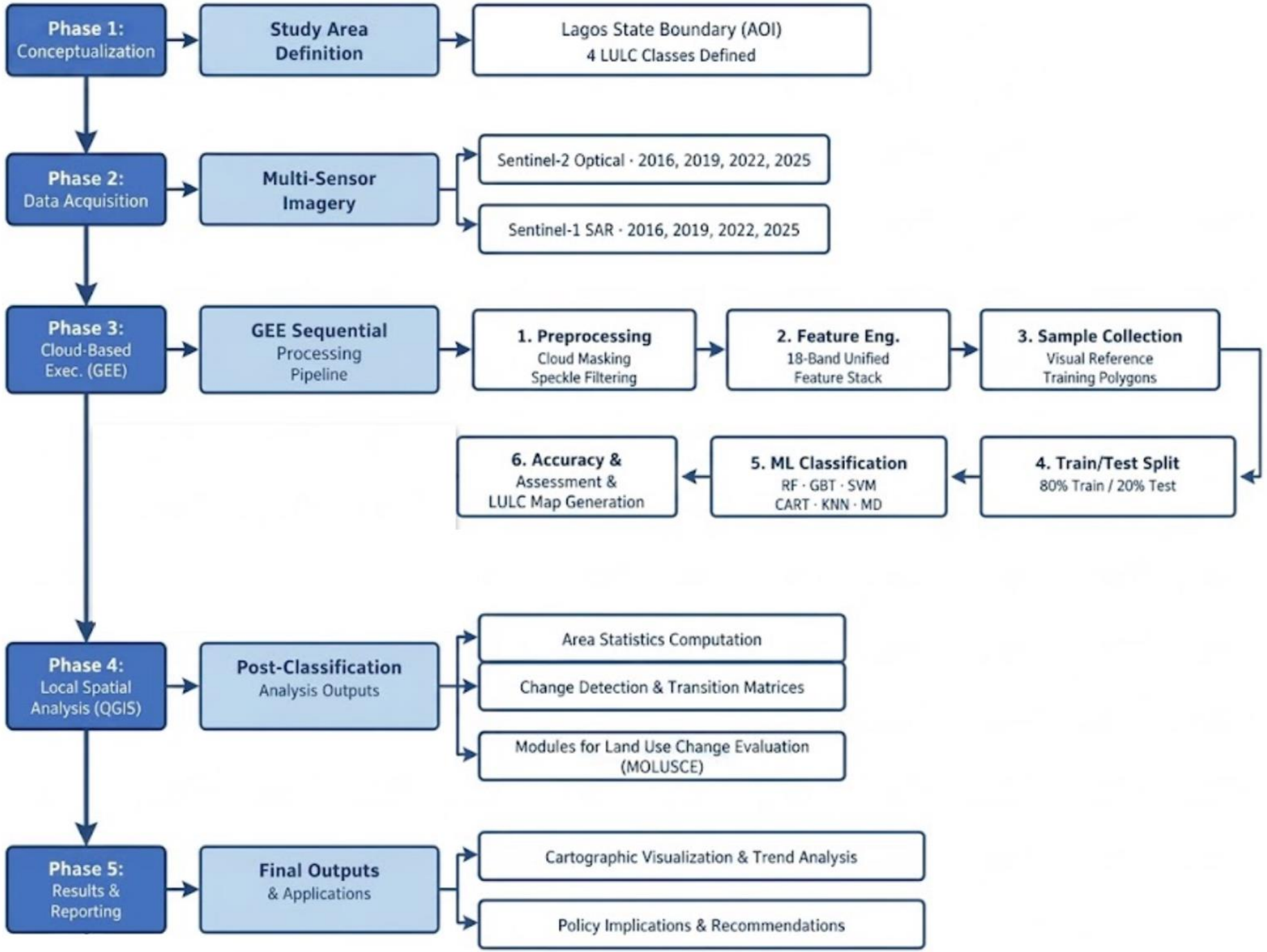
Computational Architecture

Phase 1 (Cloud): Google Earth Engine (JavaScript API) to bypass multi-terabyte processing bottlenecks.

Phase 2 (Local): QGIS utilized for spatial and ecological modelling.

Hardware: Dell Precision 7520 mobile workstation (for local geoprocessing).

METHODOLOGY



Results

Change Table for 2016 – 2019

	Δ (ha)	Δ (%)
Built-up	-16314.84	-4.45
Vegetation	12594.33	3.43
water	-474.13	-0.13
Bareland	4194.63	1.14

Change Table for 2019 – 2022

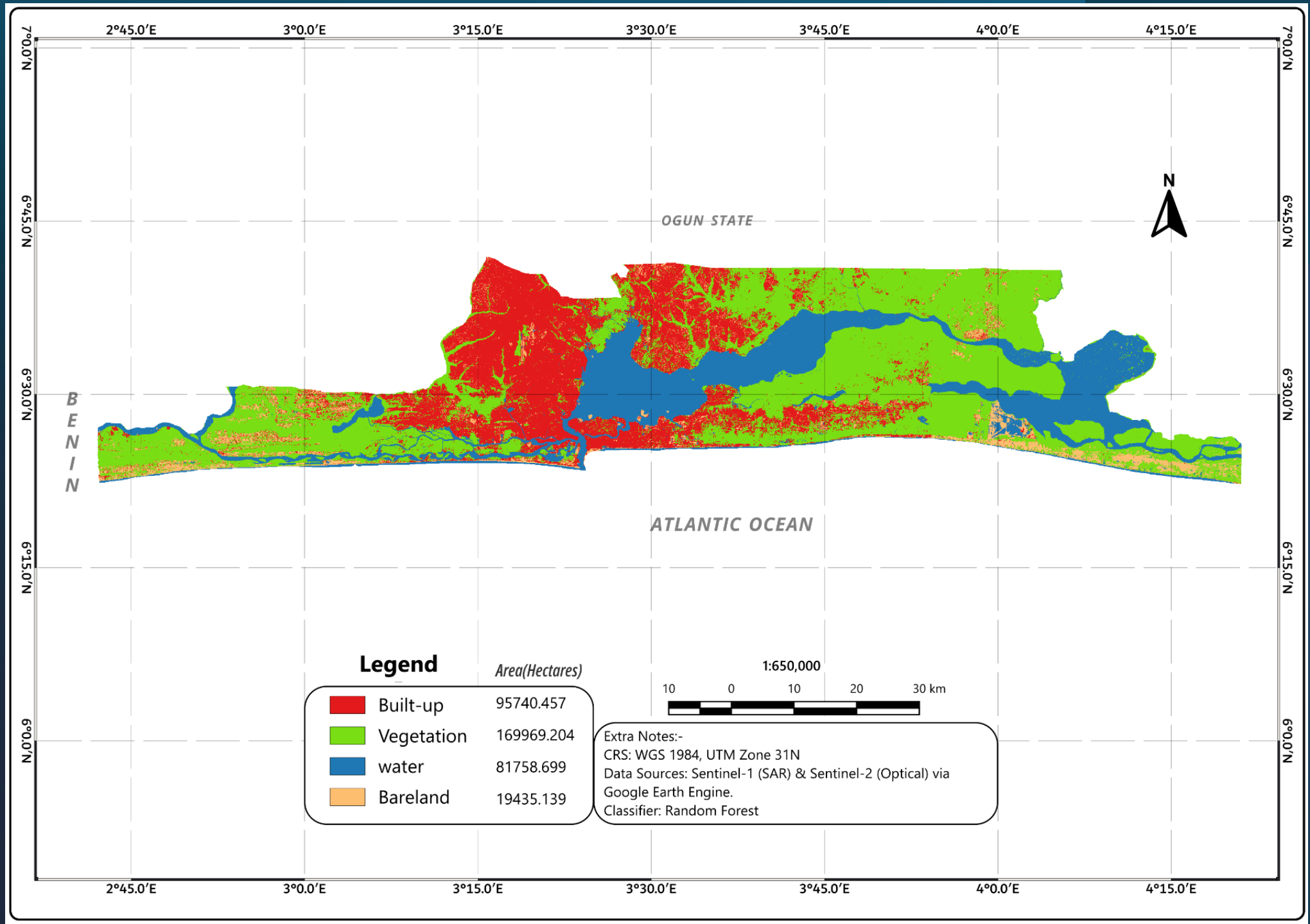
	Δ (ha)	Δ (%)
Built-up	1522.52	0.41
Vegetation	-20438.64	-5.57
water	-3900.03	-1.06
Bareland	22816.15	6.21

Change Table for 2022 – 2025

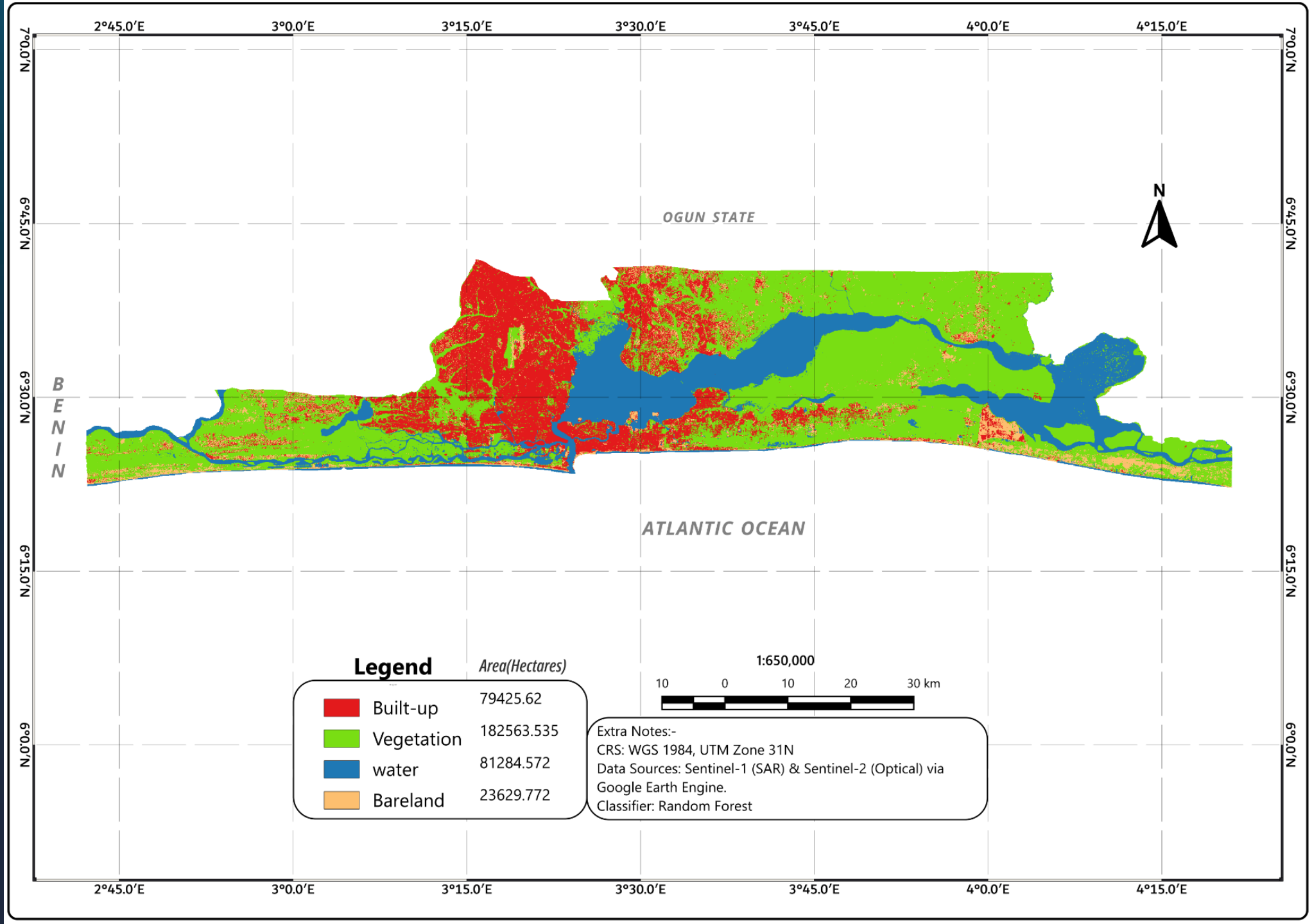
	22-25 Δ (ha)	22-25 Δ (%)
Built-up	13718.67	3.74
Vegetation	1435.12	0.39
Water	1196.98	0.33
Bareland	-16350.78	-4.46

RESULTS

2016 Map



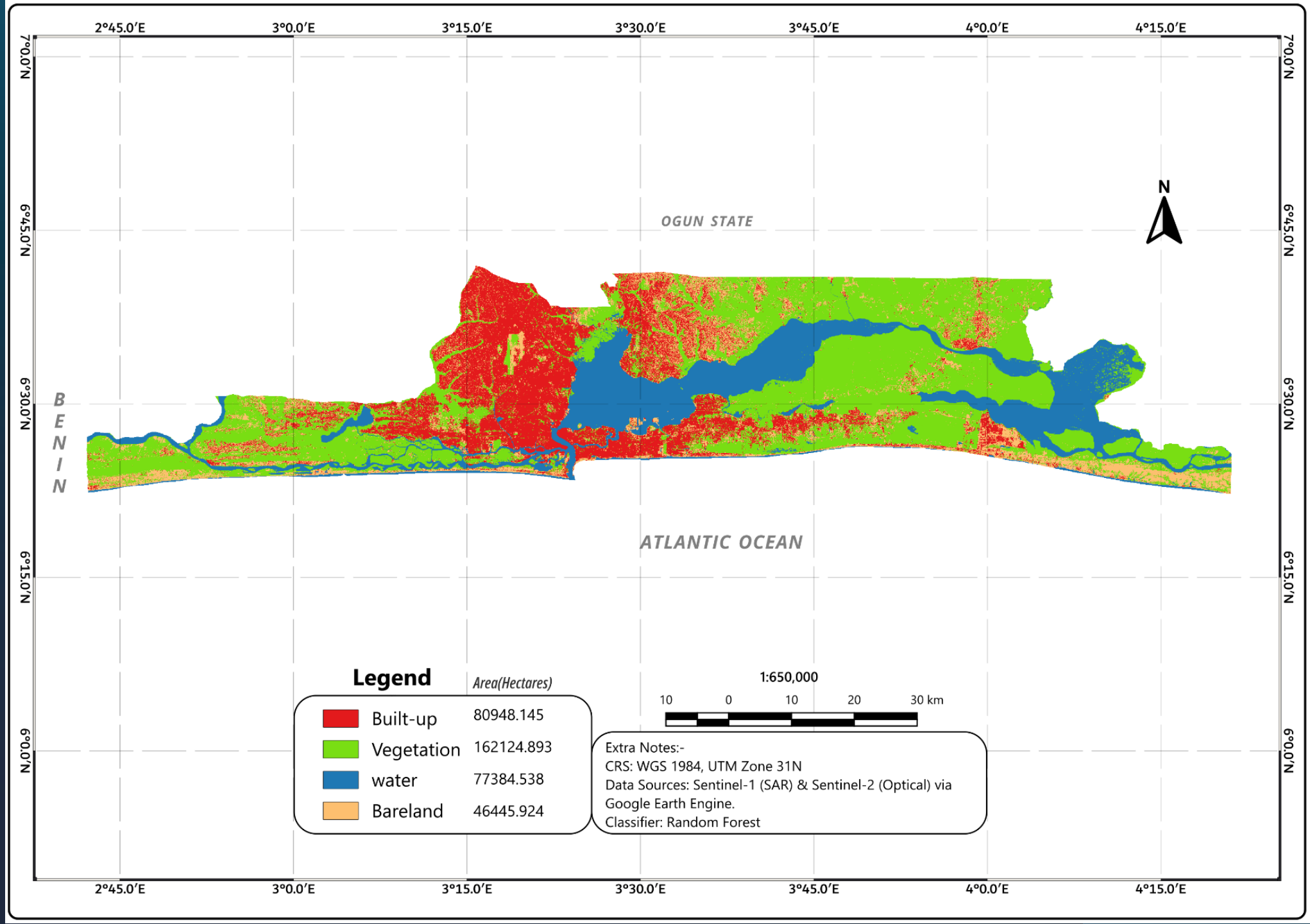
RESULTS



2019 Map

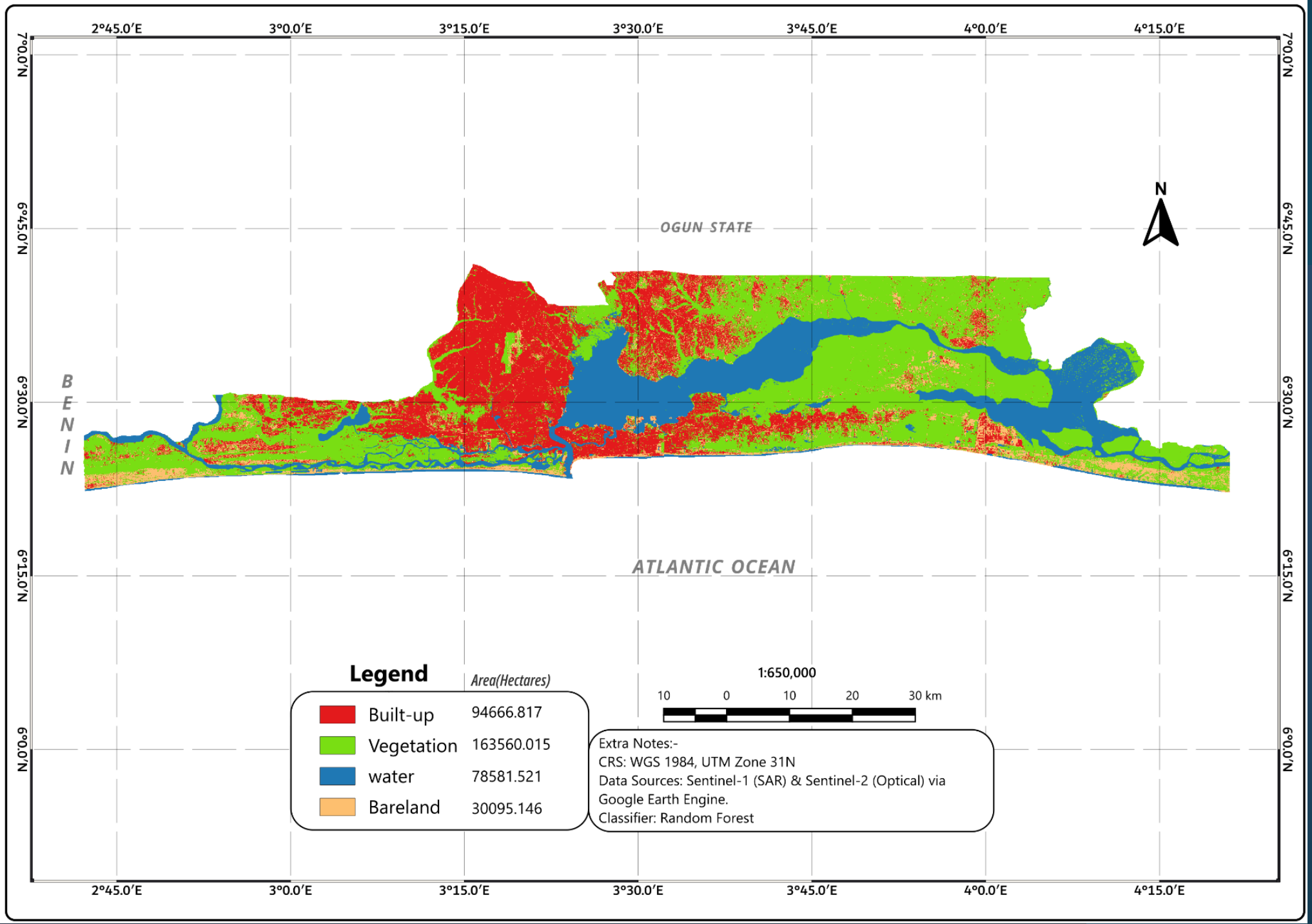
RESULTS

2022 Map

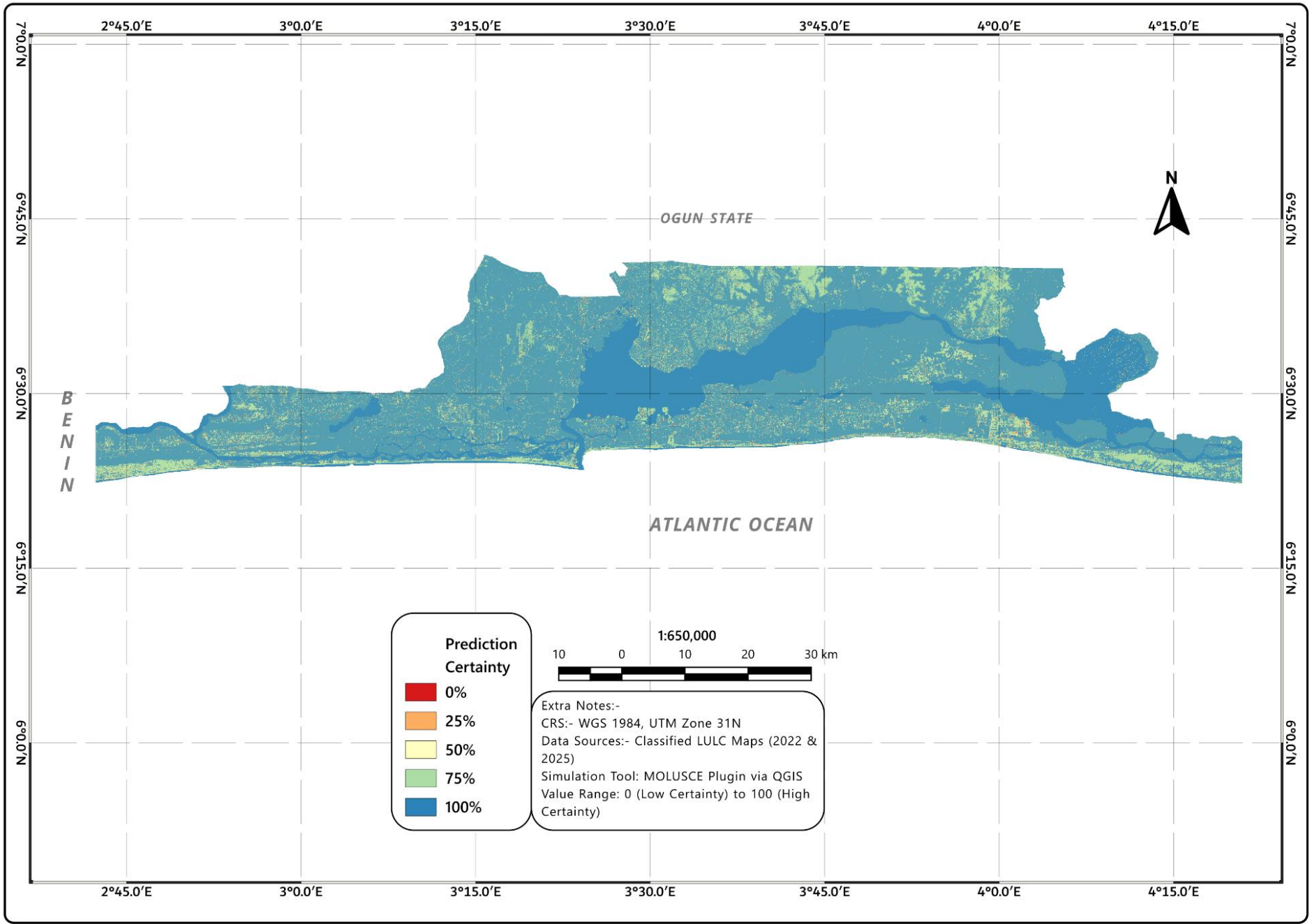


RESULTS

2025 Map



RESULT – Prediction evaluation



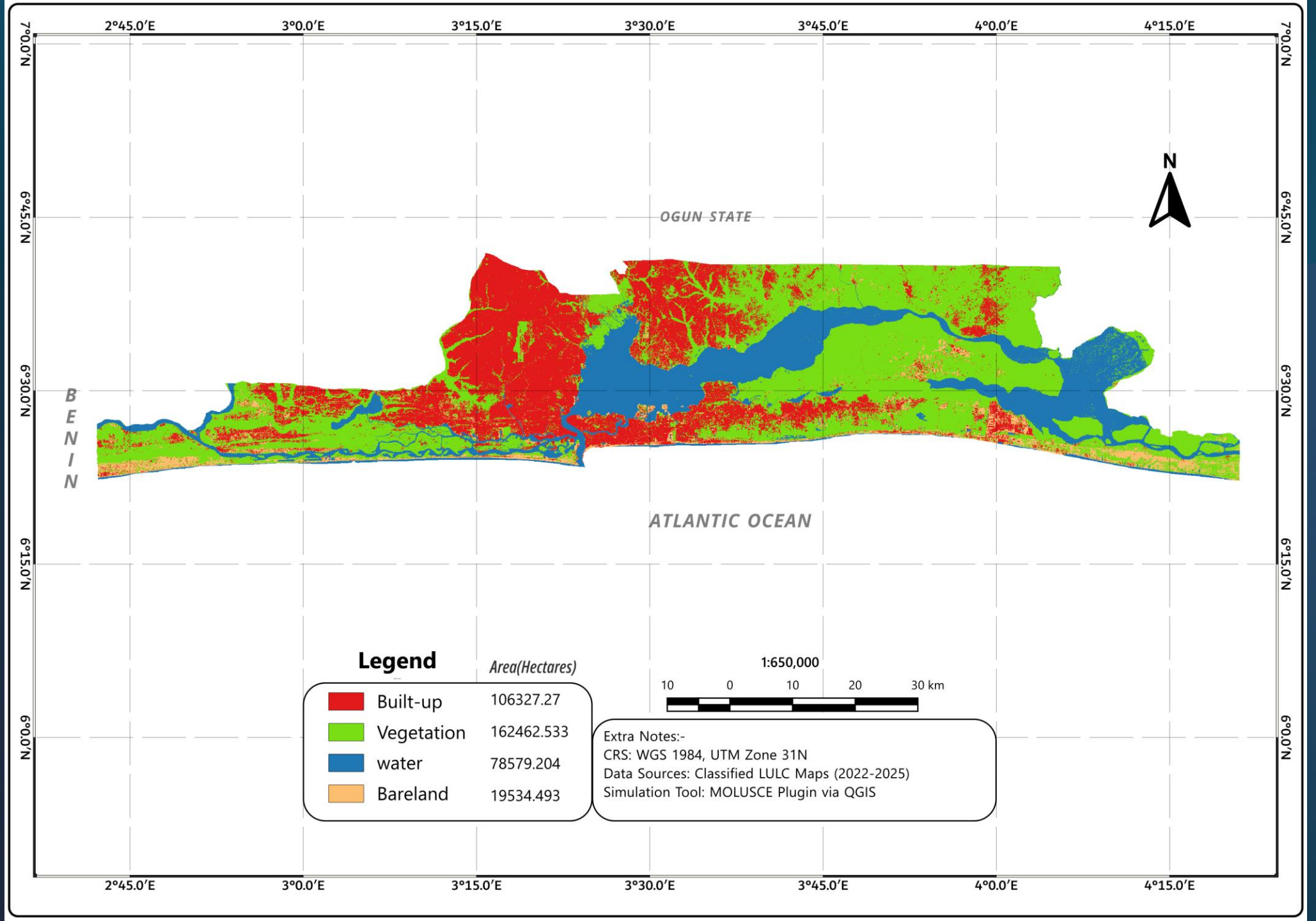
The validation process demonstrated strong predictive performance.

2022 prediction: **86.62% correctness**

2025 prediction: **85.36% correctness**

To the Left is the **Certainty function map for 2028**, which shows how certain the model is of its prediction for a particular cell.
(2022 and 2025 certainty function maps are in the report)

RESULTS


2°45.0′E
3°0.0′E
3°15.0′E
3°30.0′E
3°45.0′E
4°0.0′E
4°15.0′E
7°0.0′N
6°45.0′N
6°30.0′N
6°15.0′N
6°0.0′N
N
OGUN STATE
BENIN
ATLANTIC OCEAN
Legend
Area(Hectares)
Built-up 106327.27
Vegetation 162462.533
water 78579.204
Bareland 19534.493
1:650,000
10 0 10 20 30 km
Extra Notes:-
CRS: WGS 1984, UTM Zone 31N
Data Sources: Classified LULC Maps (2022-2025)
Simulation Tool: MOLUSCE Plugin via QGIS

Projected 2028 LULC Scenario

The predictive model (validated at >85% historical correctness) forecasts further urban expansion, heavily consuming transitional buffers.

LULC Class	2025 Area (ha)	Projected 2028 (ha)	Net Change (ha)	2028 State Coverage
Built-up	94,666.82	106,327.27	**+ 11,660.45**	28.98%
Vegetation	163,560.01	162,462.53	- 1,097.48	44.28%
Water	78,581.52	78,579.20	- 2.32	21.42%
Bare Land	30,095.15	19,534.49	**- 10,560.65**	5.32%

Conclusion

- **Cloud-Resilient Methodology:** Successfully integrated multi-sensor satellite data (SAR and optical) with machine learning via GEE to bypass tropical cloud limitations.
- **Relentless Urban Expansion:** Tracked over 13,700 hectares of new built-up infrastructure consuming vital vegetation and bare land in just three years.
- **Predictive Planning Baseline:** The 2028 spatial forecast provides actionable data to shift from reactive management to proactive, sustainable urban planning.

Thank you for your time