

StatEO

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Building a national rural road network for census operations in Brazil using multi-source geospatial data fusion

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RURAL ACESS: VITAL FOR AGRICULTURAL CENSUS



Brazil's rural landscape contains vast areas with limited or entirely undocumented road infrastructure.



Without a rural road network, logistical planning is compromised, directly threatening the statistical quality of the national census.

SYSTEMIC FAILURES IN EXISTING ROAD DATA

Coverage and fragmentation



Coverage gaps in remote regions lead to a fragmented, disconnected network.

Topologic and geometric error



Inconsistencies in scale and topology create broken routing geometries.

Coverage and fragmentation



Standardizing diverse road data for census frameworks is essential, as external layers often lack the topological precision needed for territorial coverage.

MULTI SOURCE DATA INTEGRATION



Open sources

Integration of Overture Maps and OpenStreetMap as reference foundational layers.



Planet

Extraction of centerlines from the Planet Full Roads product to fill coverage gaps.

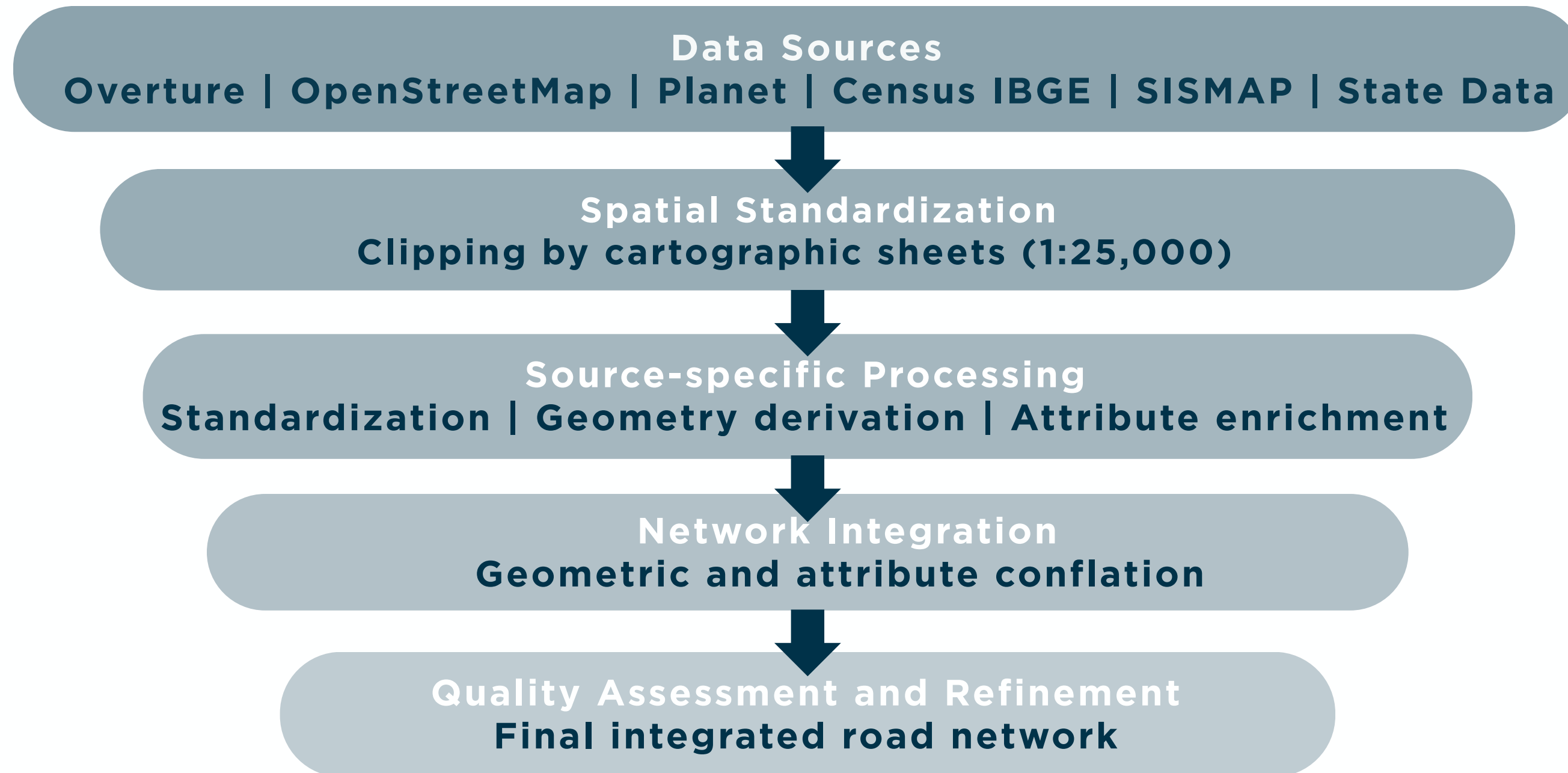


IBGE Data

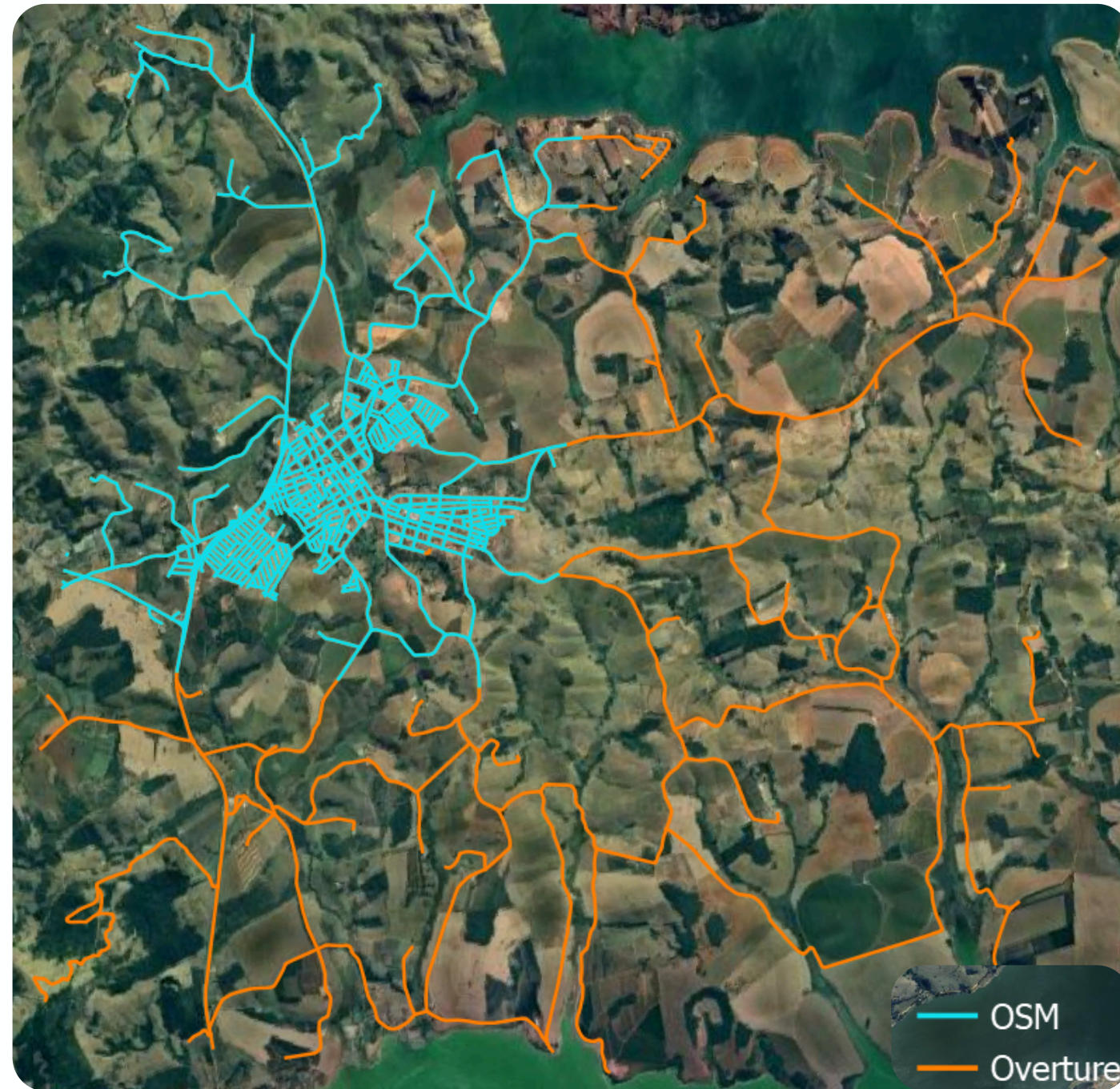
Consolidating historical agricultural census units and internal operational road datasets.



METHODOLOGY



RURAL ROAD COVERAGE EVOLUTION



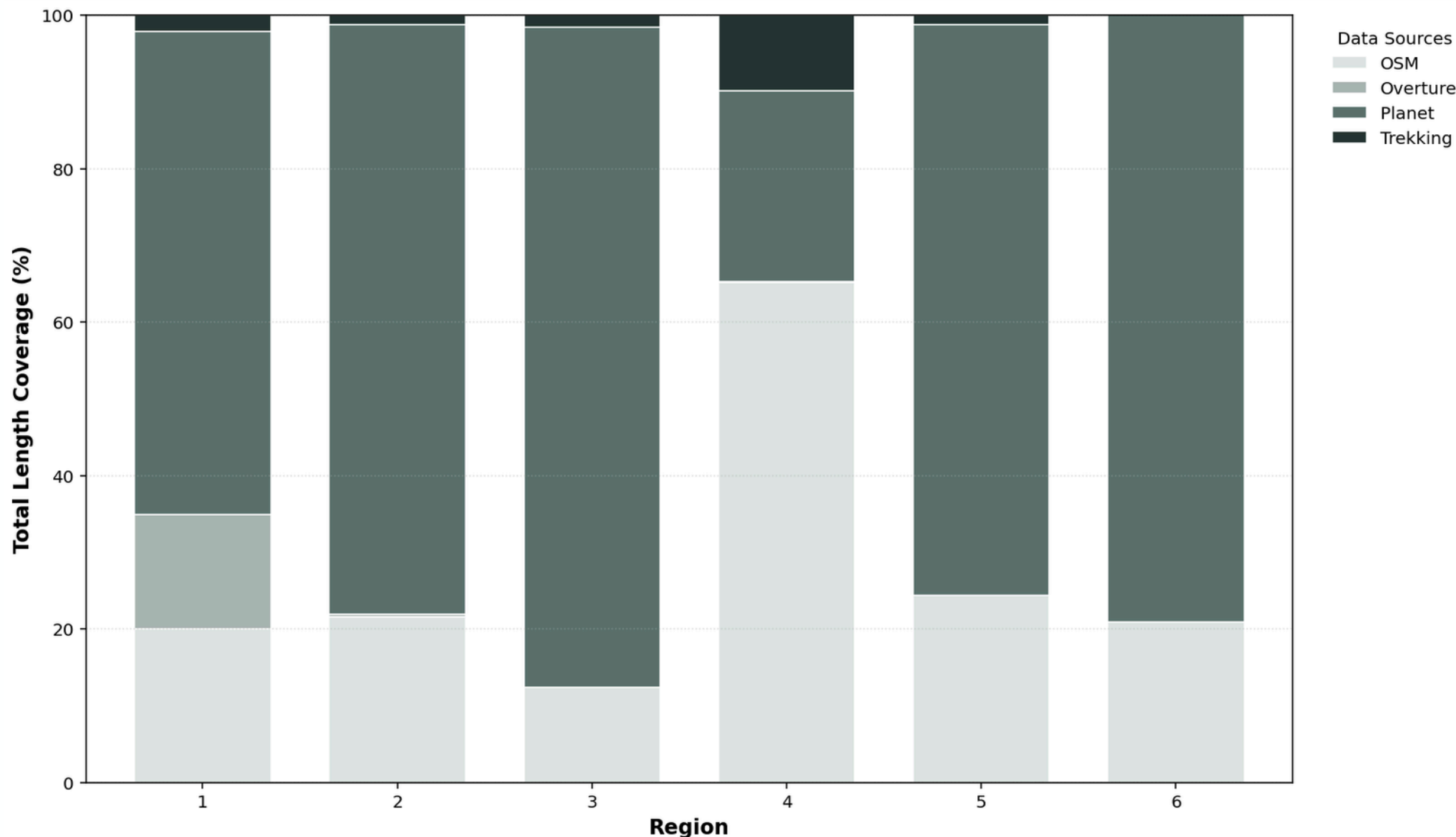
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RURAL ROAD COVERAGE EVOLUTION

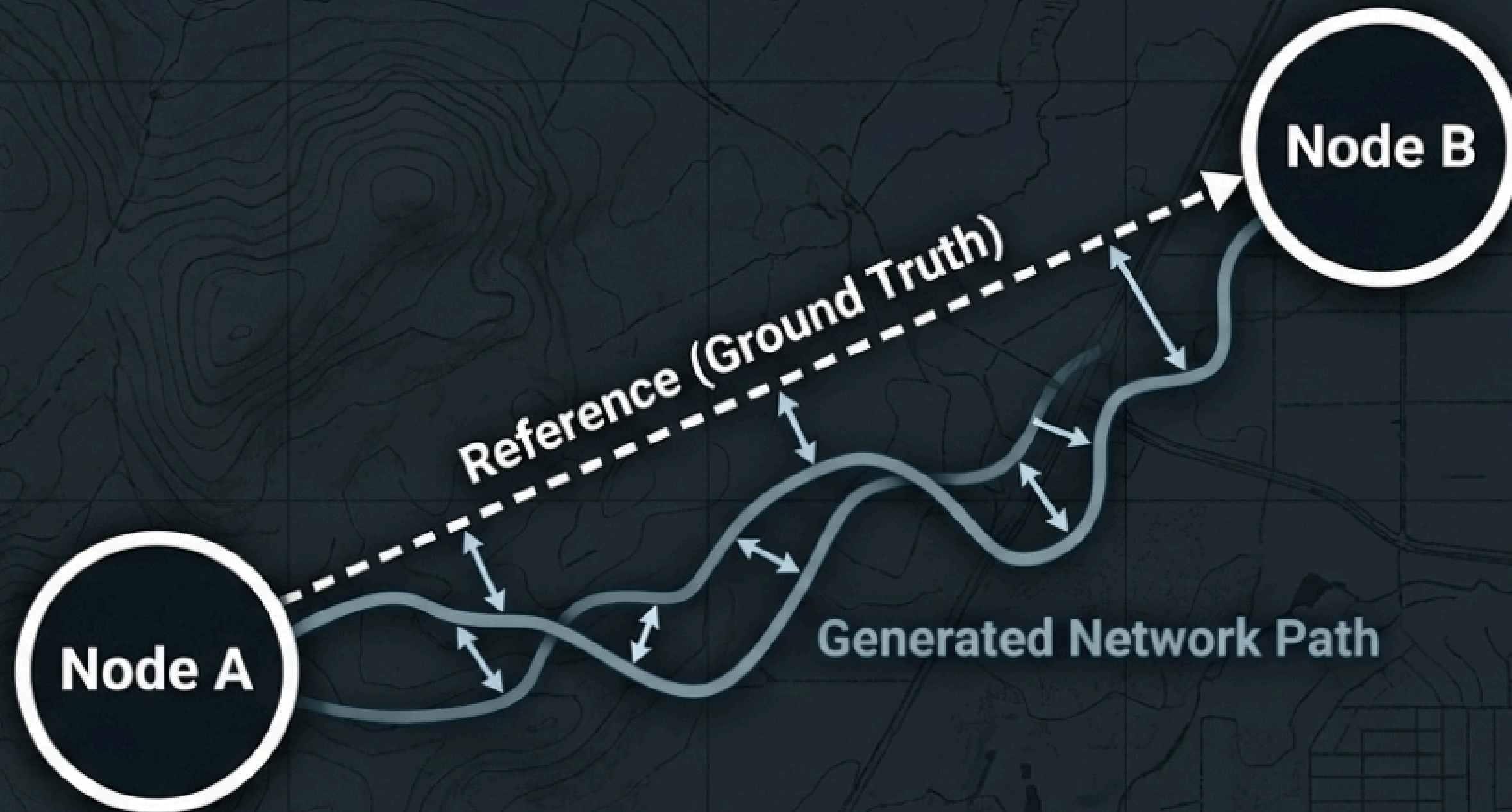


TOTAL LENGTH COVERAGE (%)

**Integration:
OSM + Overture +
Planet + Trekking**



ROAD NETWORK VALIDATION METRICS



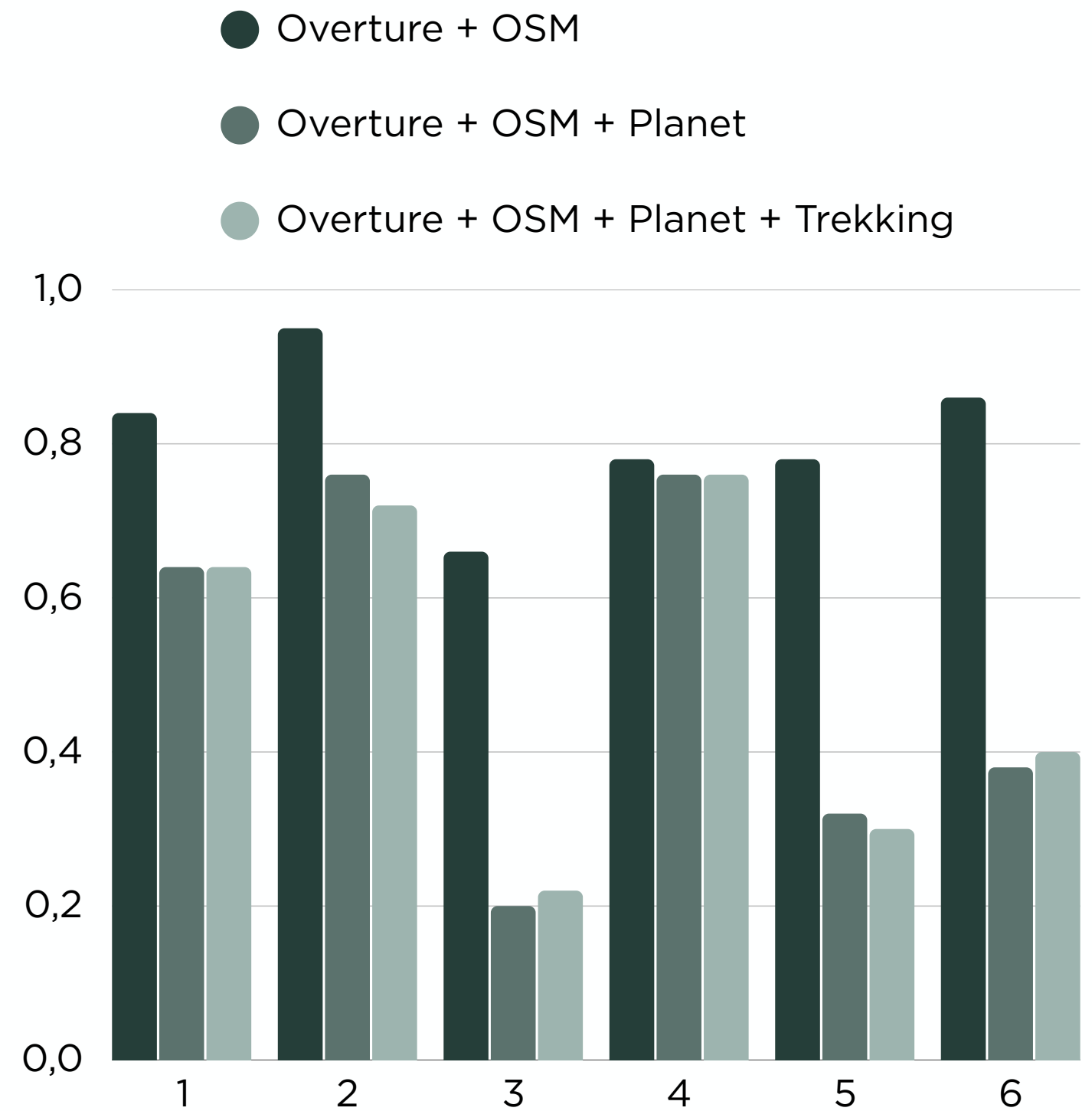
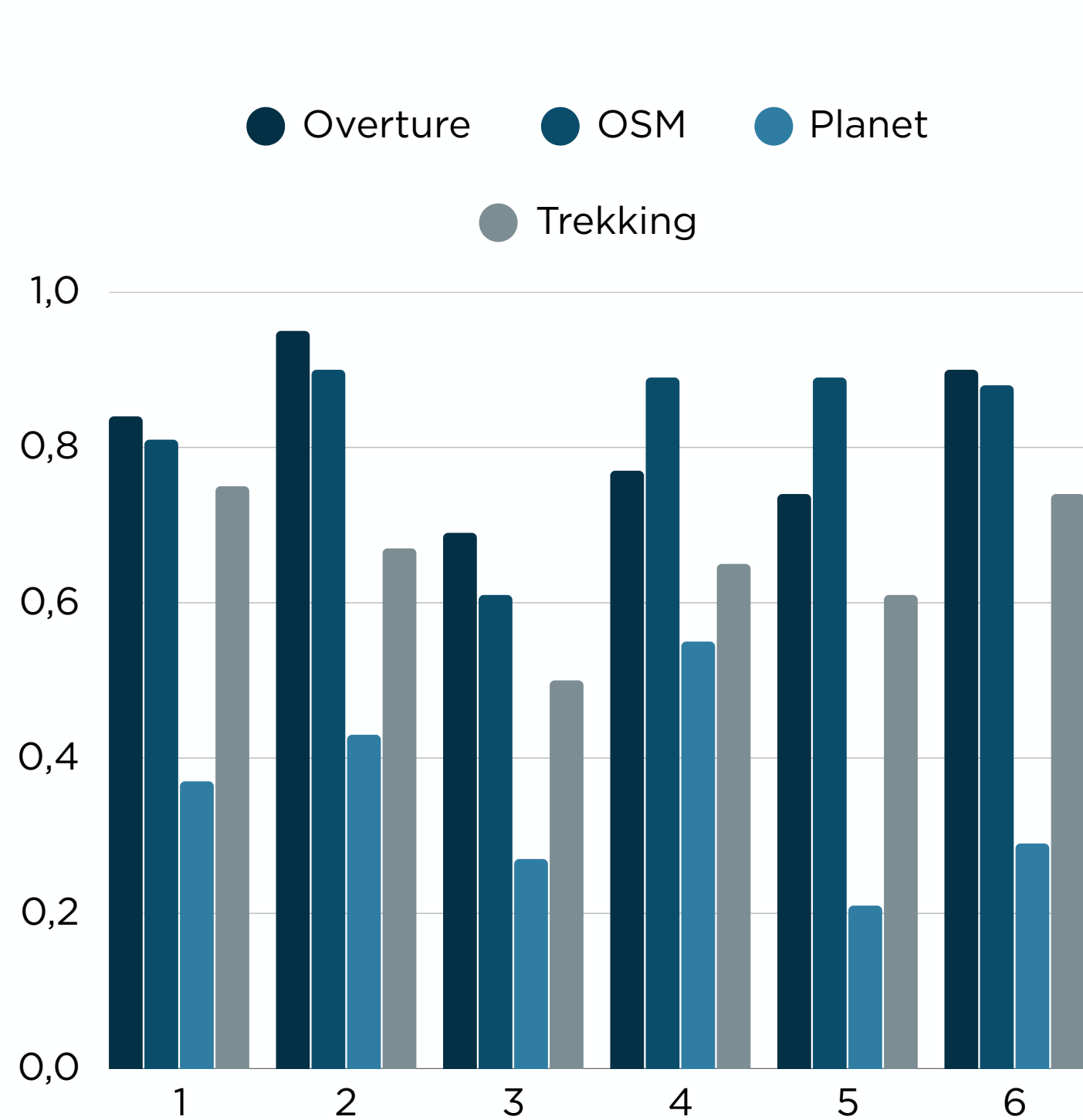
APLS Evaluation:

Measures the shortest path comparison between the reference network and the generated network.

Evaluates true routing-based connectivity rather than just raw pixel overlap.

Functions as a bidirectional metric to ensure realistic transit times for census enumerators.

APLS (Average Path Length Similarity) METRIC



IMPROVED ROAD CONNECTIVITY AND PROXIMITY IN RURAL AREAS

2,14

Average connected components per area

Analysis based on 106 enumeration areas

Indicates moderate network connectivity and partial network integration.

32,19

Mean distance to nearest road

Median: 18,85 | Based on 8,526 agricultural holdings

Most are relatively close to the road network, with high spatial variability and remote outliers.

> 97%

Agricultural holdings closer than 330mts to a road

8,526 agricultural holdings

Only less than 3% are located far from an identified access

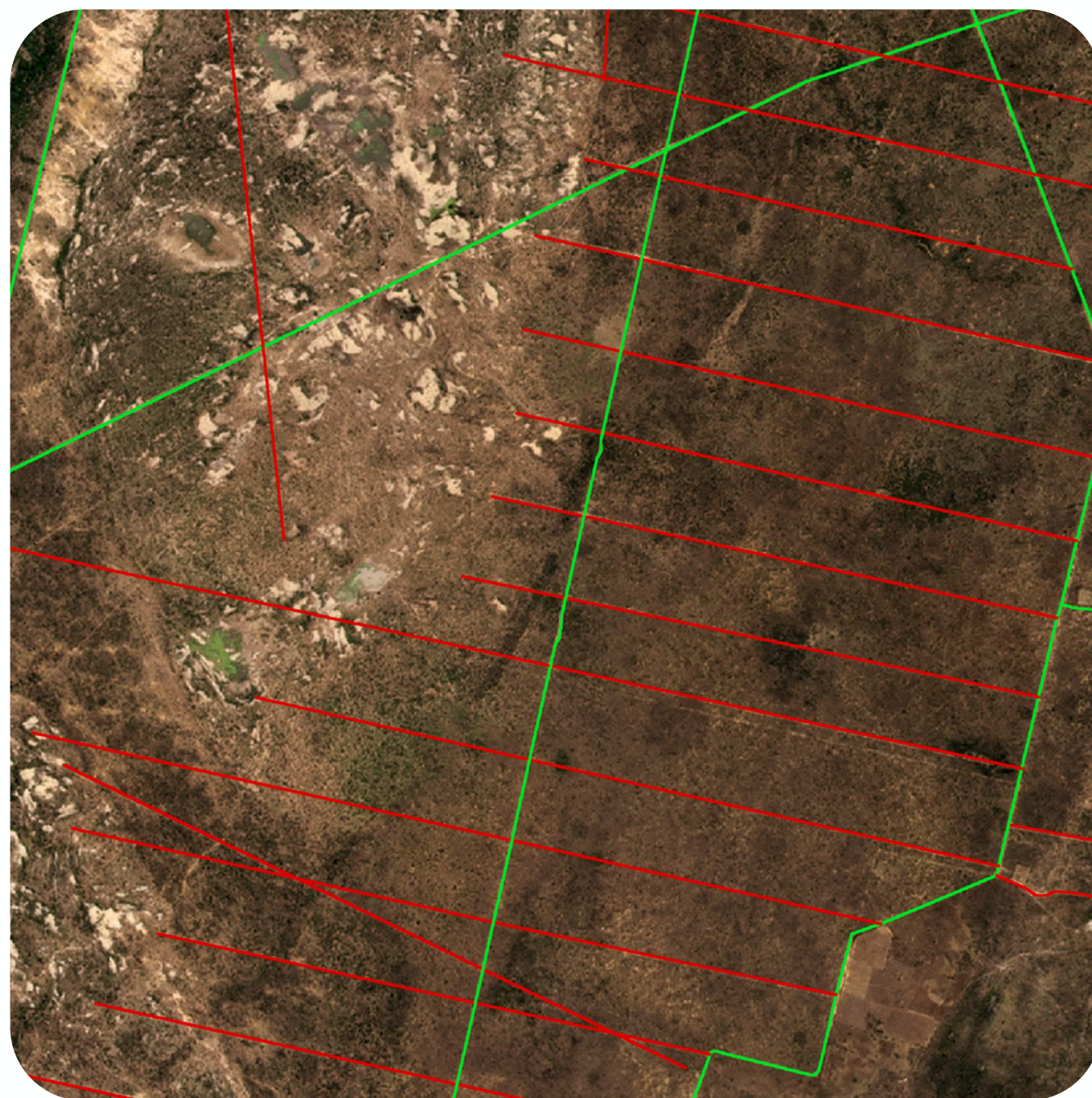
DEEP LEARNING FOR ROAD EXTRACTION

Extraction Performance Metrics



Quantitative results evaluating the D-LinkNet model across complex, ambiguous terrain distinguishing navigable paths from non-roads.

DEEP LEARNING FOR ROAD EXTRACTION



Ground Truth



Model Prediction

-  Public and private roads
-  Non-path

DEEP LEARNING FOR ROAD EXTRACTION



Ground Truth



Model Prediction

- Public and private roads
- Non-path

FUTURE WORK

Impact on the Agricultural Statistics, Census and Public Policies

- Scaling the methodology for national-level deployment.
- Dynamic monitoring through Earth Observation (EO) data streams.
- Interoperability with IBGE's core operational ecosystems and statistical frameworks.
- Automated, auditing of road network quality and accessibility.
- Advancing SDG Target 9.1.1 by quantifying rural accessibility through geospatial intelligence.

ACKNOWLEDGEMENTS



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Thank you.