

NDRE and NDVI Vegetation Health Analysis near Ilva Steel Plant (2018–2024)

Case Study Presentation

Earth Observation Module A [2023-24]

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Credit: Mondadori Portfolio

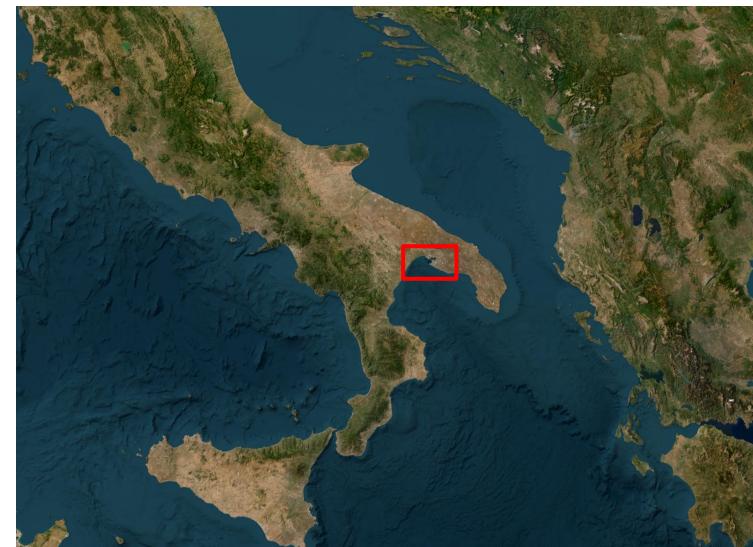
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Overview

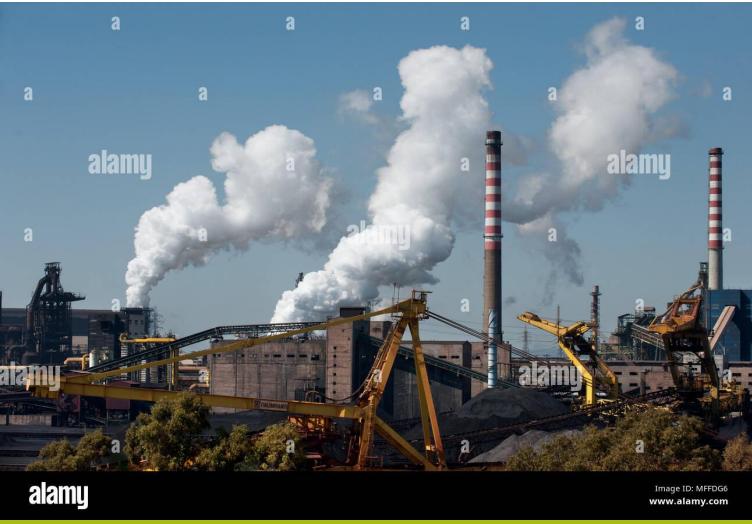
Ilva Steel Plant



The Ilva Steel Plant began operations in 1965 in Taranto, Italy. Is one of the **largest steel production facilities in Europe**. The plant has been a significant contributor to the local economy but also a **major source of pollution and environmental concern**.



Since the 1990s, **environmental regulations** have tried to **reduce emissions**. After ArcelorMittal acquired the plant in 2018, €1.1 billion has been assigned for **environmental reforms**, but progress has been **slow**.



Motivation and Objective



Motivation

To assess whether these reforms have improved the health of the surrounding vegetation, this study uses multispectral images from 2018 and 2024 to track changes in vegetation health.



Objective

The project compares NDVI and NDRE indices from 2018 and 2024 to evaluate the impact of Ilva's environmental reforms on vegetation health within a 10 km radius of the plant.



Methodology

1. Data Procurement

COPERNICUS BROWSER: MULTISPECTRAL IMAGES

2018

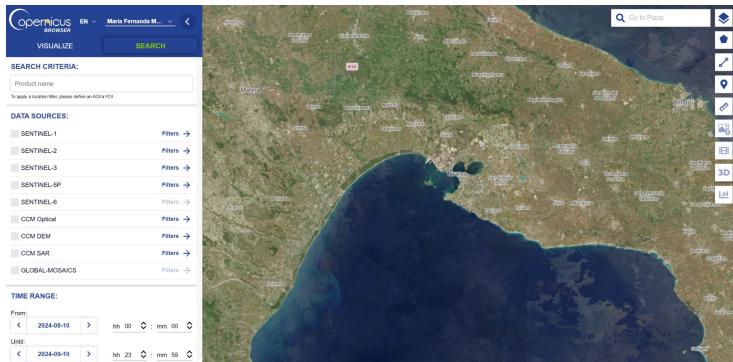
- Tile with less cloud coverage in 2018 between April - August (Spring - Summer):
 - Date: 25-05-2018
 - Time: 09:40:29
 - Average temperature of the week: 16-26
 - Cloud_Coverage_Assessment: 1.914765

Product ID: S2B_MSIL2A_20180525T094029_N0500_R036_T33TXE_20230823T052253.SAFE

2024

- Tile with less cloud coverage in 2024 between April - August (Spring - Summer):
 - Date: 07-06-2024
 - Time: 09:40:41
 - Average temperature of the week: 20-30
 - Cloud_Coverage_Assessment: 0.570151

Product ID: S2A_MSIL2A_20240607T094041_N0510_R036_T33TXE_20240607T123352.SAFE

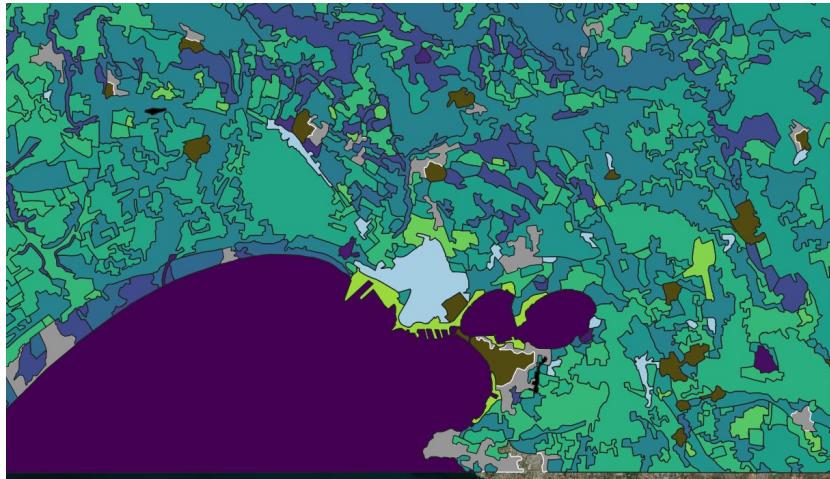


1. Data Procurement

COPERNICUS LAND MONITORING SERVICE: CORINE LAND COVER VECTOR

The CORINE Land Cover inventory provides comprehensive land cover data for Europe, classifying land into 44 thematic categories with an update frequency of 6 years. It's available in raster and vector.

2018



2024

No data Available yet

2. Data Pre-processing

Reprojection of Vector Layer:

- Reproject the CORINE 2018 LAND COVER VECTOR LAYER from EPSG:3035 (ETRS89-extended) to match the multispectral image's projection, EPSG:32633 (WGS 84 / UTM zone 33N).

Create a Virtual Rasters for 2018 and 2024 images:

1. For Classification: Combine bands 2, 3, 4, and 8 of the multispectral image into a virtual raster with a 10-meter resolution

Definition of Area of Interest (AOI):

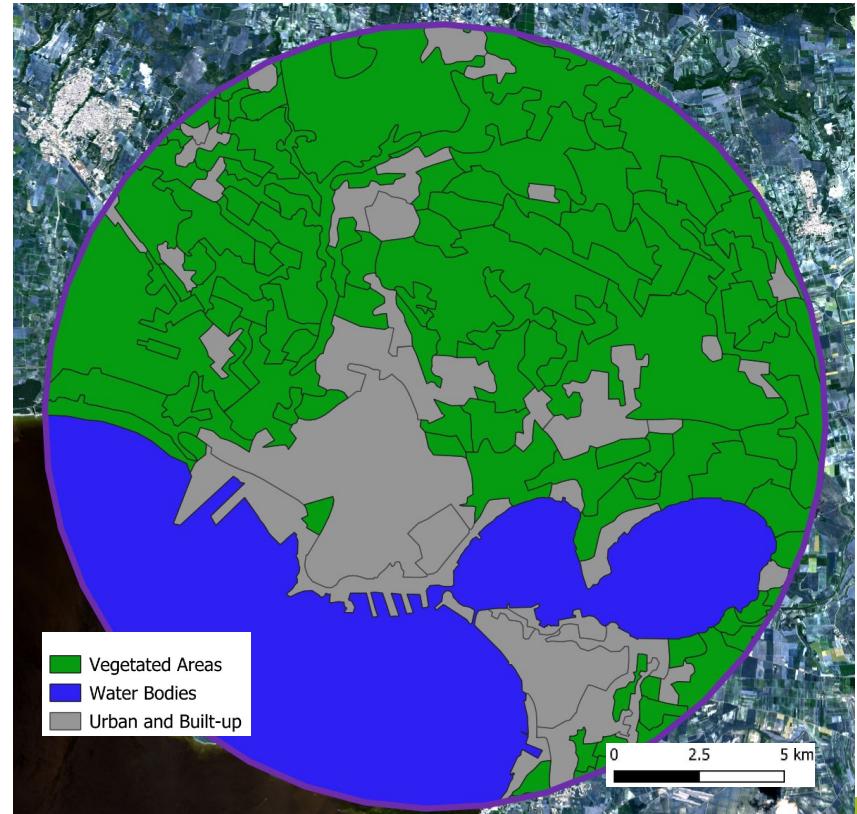
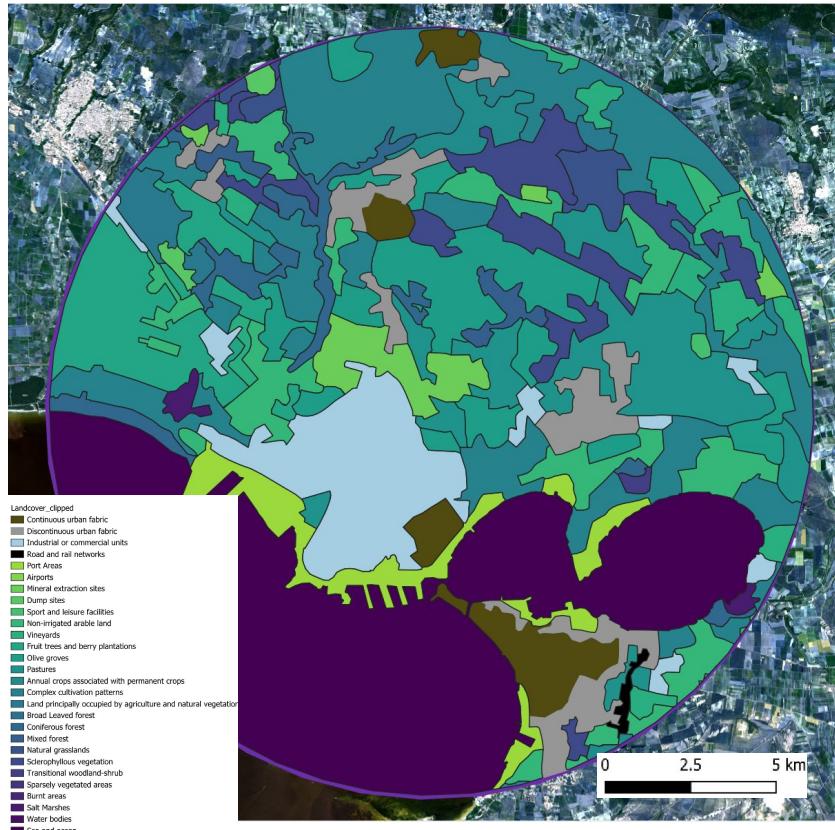
- Define a 10 km radius area centered around the Ilva Steel Plant.

Clip Rasters and Vector Layers to AOI



2. Data Pre-processing

Reclassification of vector Layer



Re-classification



Urban and Built-up Areas (3)

Continuous urban fabric

Discontinuous urban fabric

Industrial or commercial units

Road and rail networks

Port Areas

Airports

Sport and leisure facilities

Dump sites

Mineral extraction sites



Natural Vegetation (2)

Broad-leaved forest

Coniferous forest

Mixed forest

Natural grasslands

Sclerophyllous vegetation

Transitional woodland-shrub

Sparsely vegetated areas

Burnt areas

Salt Marshes

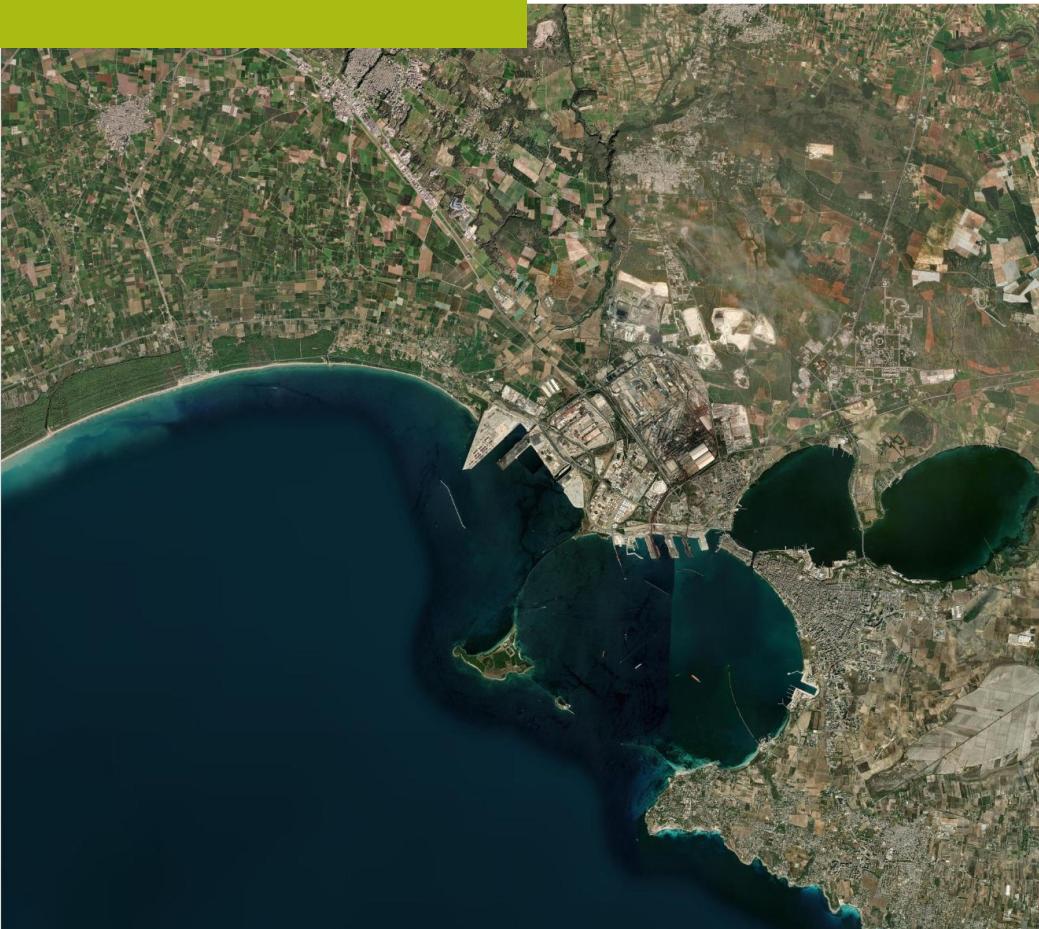


Water Bodies (1)

Water bodies

Sea and ocean

2018 |

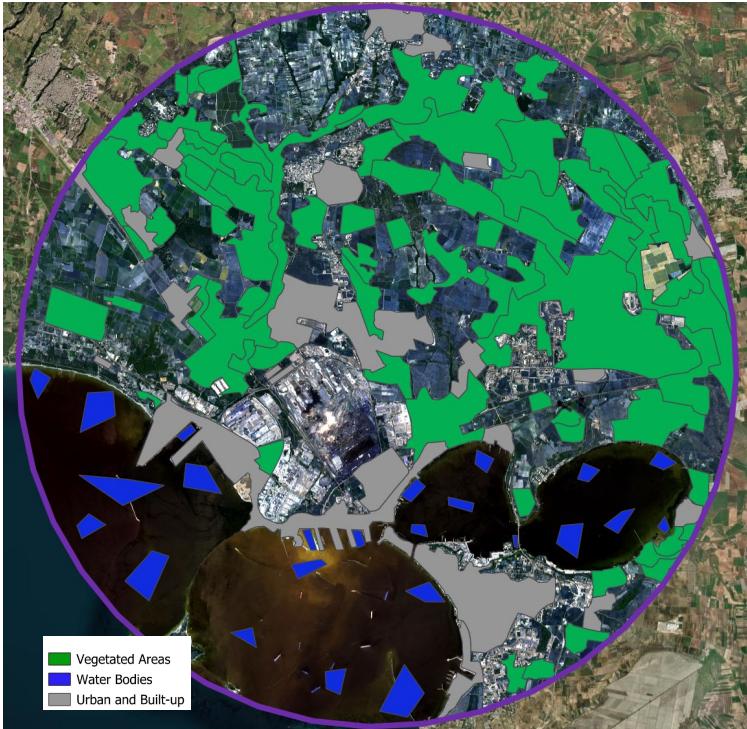


3. Supervised Classification

Training and Testing Data Set

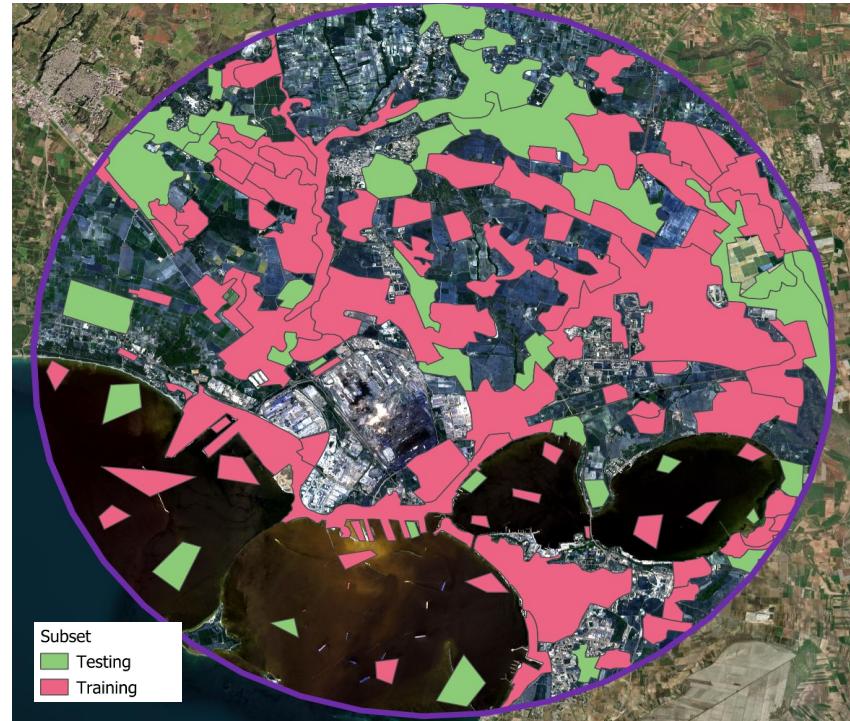
01 subset of CORINE Set

Creation of the sub-set taking into account the "most accurate features"



02 Training and Testing Features Selection

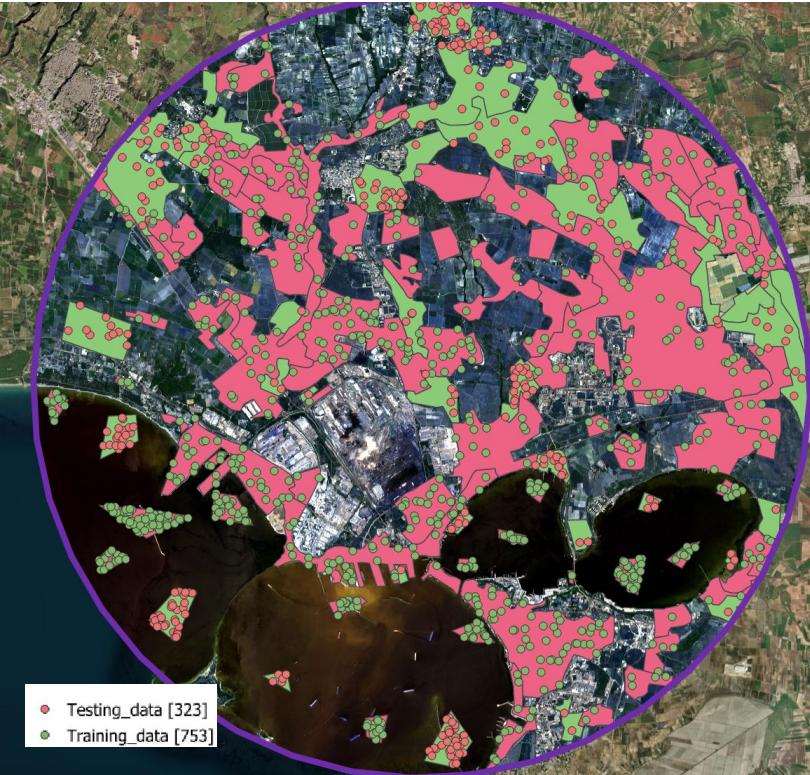
70% for training and 30% for testing



3. Supervised Classification

Training and Testing Data Set

03 Creation of random point on the features



In order to ensure a good representation of each class and to reduce the complexity when training. Random Points were generated on each polygon and used for the training and testing: 1076 points were created:

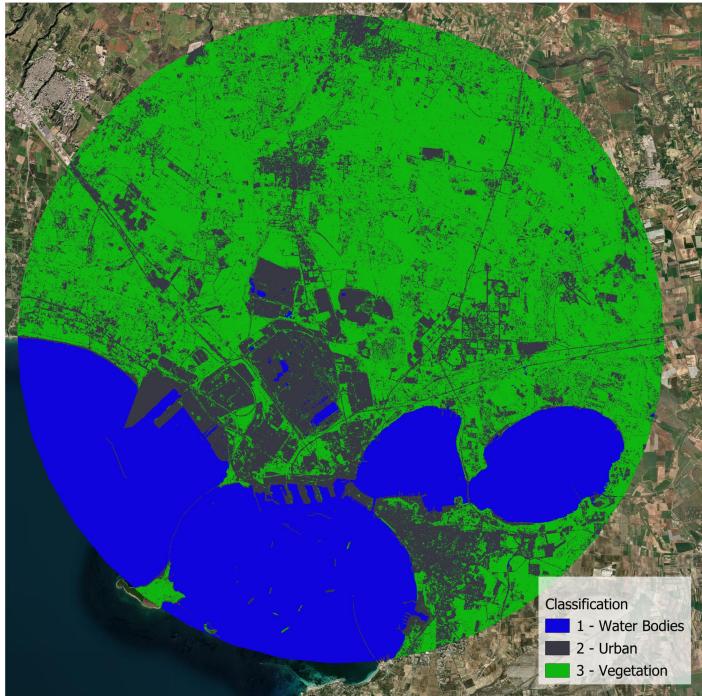
- 70% for training - 753
- 30% for testing - 323

Type	Label	Test_Train	Number of points
Vegetation	3	Training	251
		Testing	108
Urban	2	Training	251
		Testing	108
Water	1	Training	251
		Testing	107

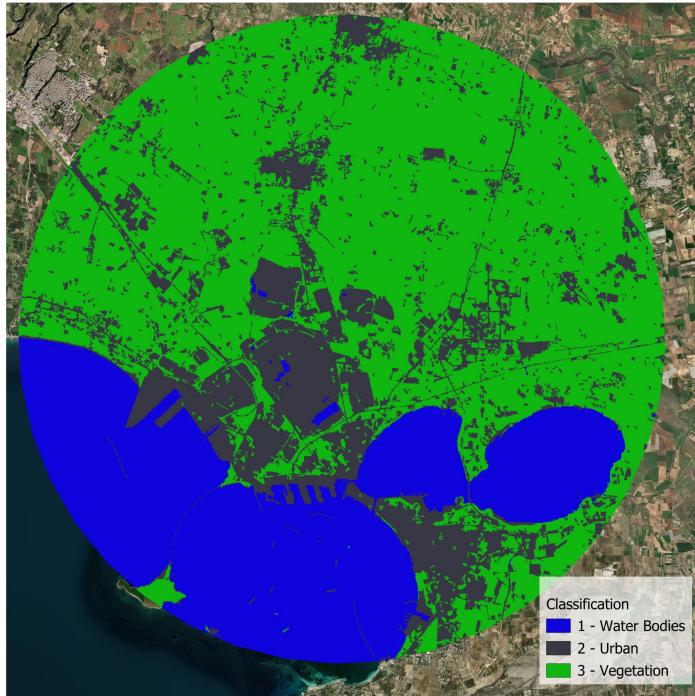
3. Supervised Classification

Classification and Accuracy Assessment

Classification 2018



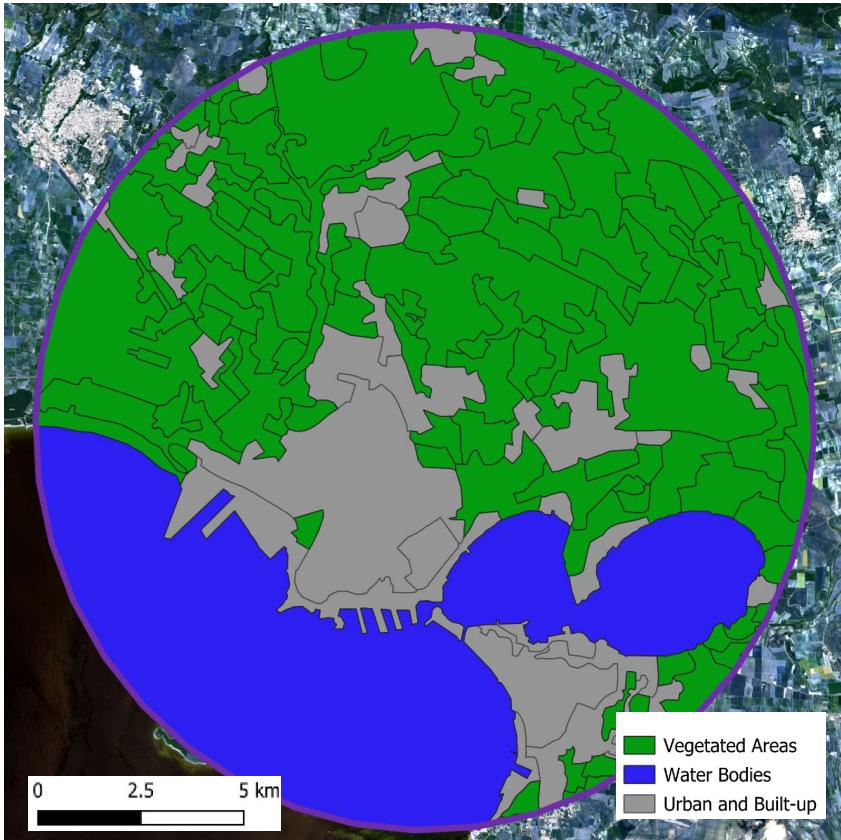
Classification Sieved (30 px)



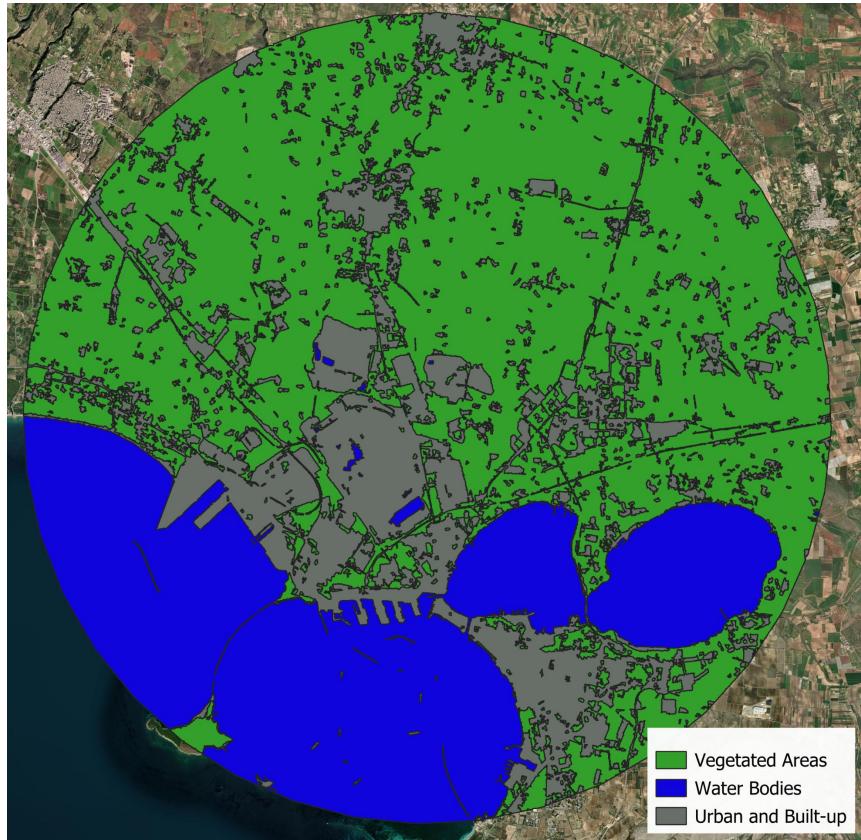
Class/Type	1	2	3	UA	PA	OA
1	106	1	0	0.99	0.99	0.78328173
2	1	63	24	0.72	0.58	
3	0	44	84	0.66	0.78	

3. Supervised Classification

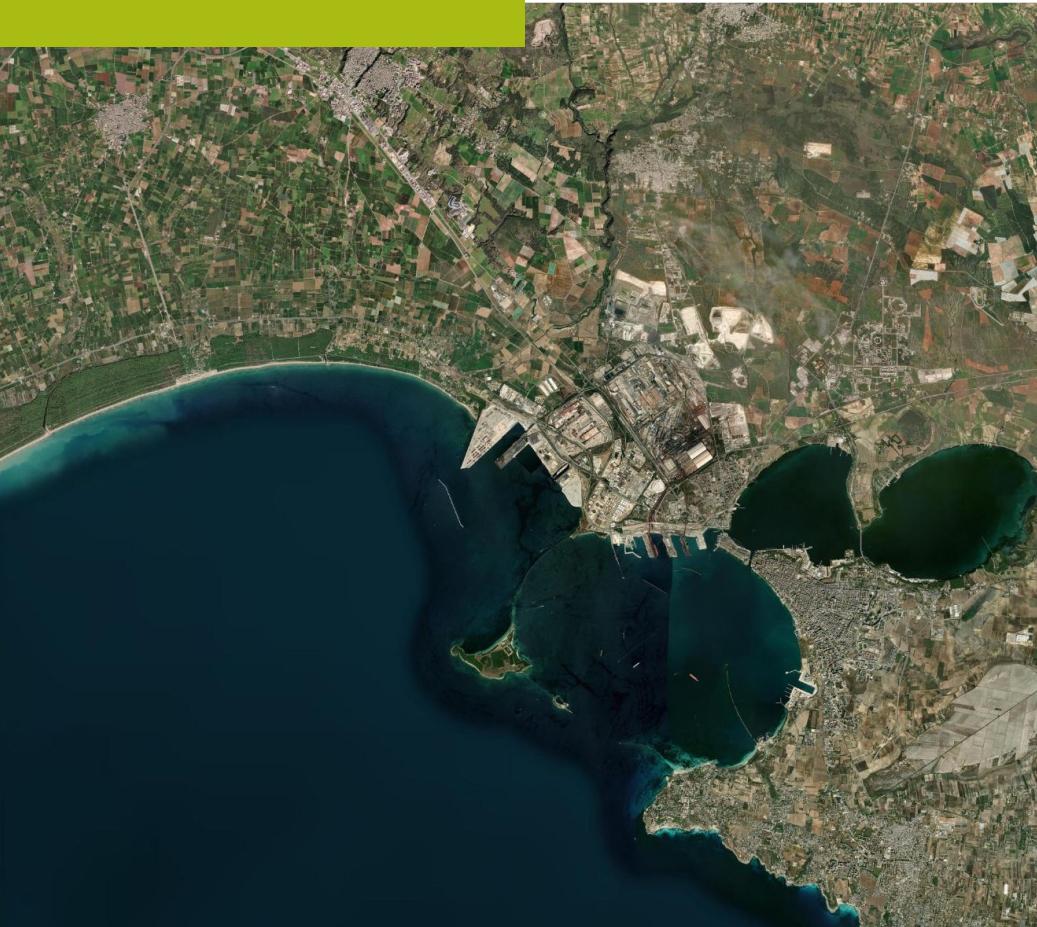
Corine 2018



Classification Vectorized



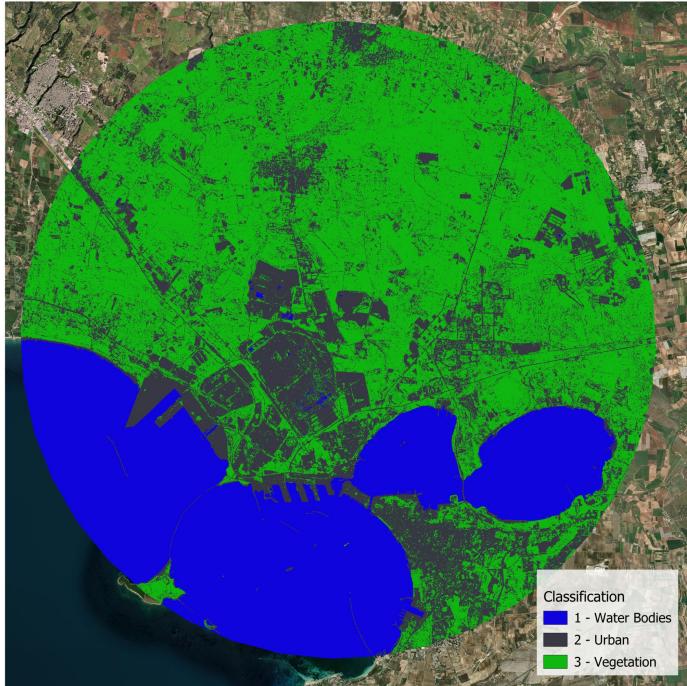
2024 |



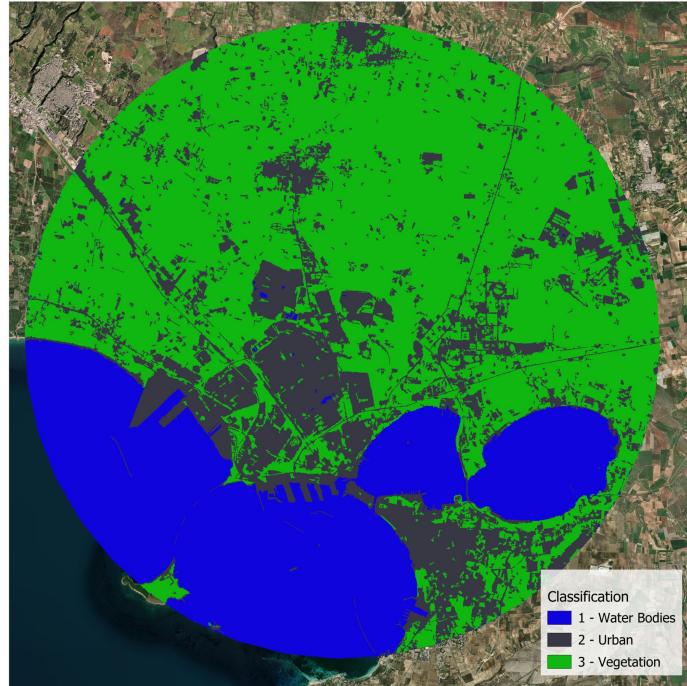
3. Supervised Classification

The model obtained with 2018 multispectral image was used to perform the Classification

Classification 2024



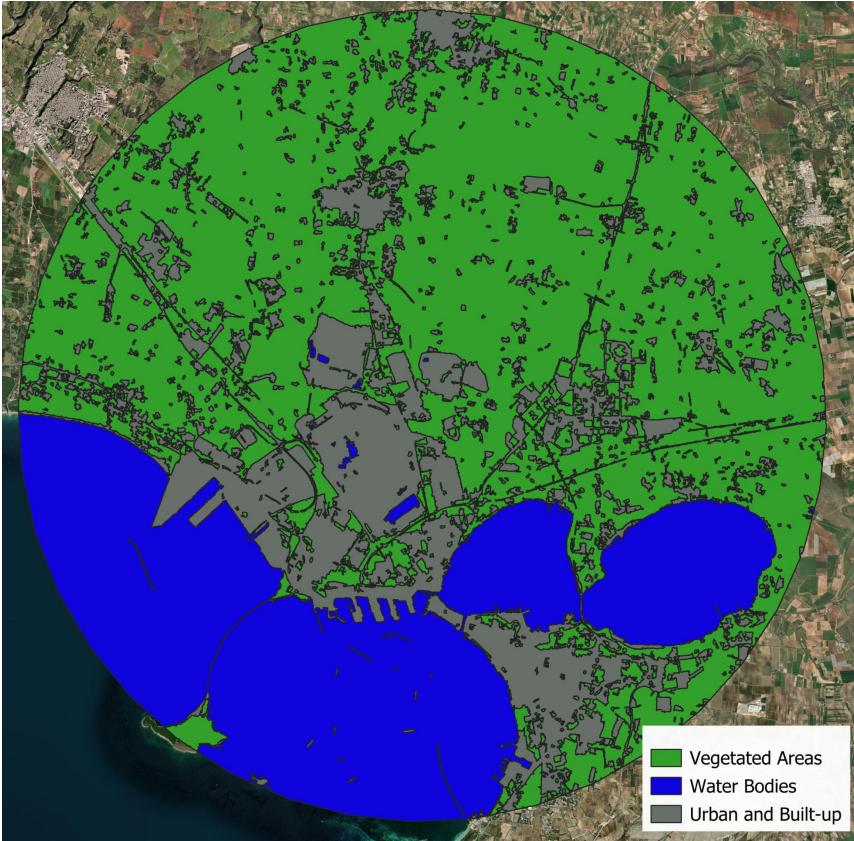
Classification Sieved



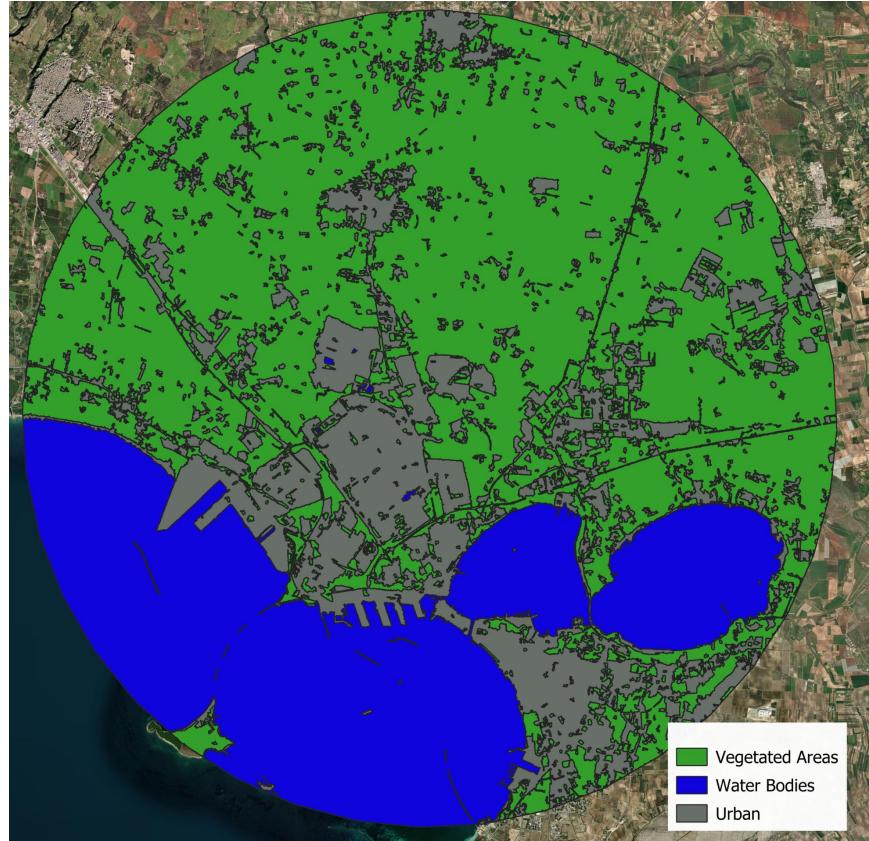
class/Type	1	2	3	UA	PA	OA
1	106	1	0	0.99	0.99	0.80495356
2	1	62	16	0.78	0.57	
3	0	45	92	0.67	0.85	

3. Supervised Classification

Classification Vectorized 2018



Classification Vectorized 2024



4. Indexes Calculation

- **NDVI - Normalized Difference Vegetation Index:**

Measure vegetation health and density by assessing the difference between near-infrared NIR (Band 8) and red light reflectance (Band 4)

- NDVI tells you about **vegetation density and greenness.**

$$\text{NDVI} = \frac{(\text{NIR} - \text{red})}{(\text{NIR} + \text{red})}$$

Interpretation:

Negative Values (around -1): Non-vegetated surfaces like water, snow, or clouds.

Near Zero (0 to 0.2): Bare soil or very sparse vegetation.

Moderate Values (0.2 to 0.5): Sparse to moderately healthy vegetation.

High Values (0.5 to 1): Healthy, dense vegetation.

- **NDRE - Normalized Difference Red Edge Index**

Is more sensitive to early vegetation stress, particularly useful for detecting subtle changes in chlorophyll content. Is measured with the difference between NIR (Band 8) and Red Edge (Band 5)

- NDRE monitors **chlorophyll content.**

$$\text{NDRE} = \frac{(\text{NIR} - \text{RE})}{(\text{NIR} + \text{RE})}$$

Interpretation:

Negative or Near Zero Values: Areas with little to **no vegetation or stressed vegetation.**

Low Positive Values (0 to 0.3): Vegetation is under stress, **such as nutrient deficiency or drought,** but it may not yet be visible.

Moderate to High Values (0.3 to 0.7 or higher): **Healthy vegetation,** with **higher chlorophyll content** indicating good overall plant health and vitality.

4. Indexes Calculation

Focusing only on the vegetated areas, the NDVI and NDRE calculations will more accurately represent the health and stress of vegetation, without being diluted by irrelevant features.

For 2018 and 2024 Bands:

- Resample Band 8 to 20 meters
- Clip Bands 4,5 and 8 to Vegetation Areas

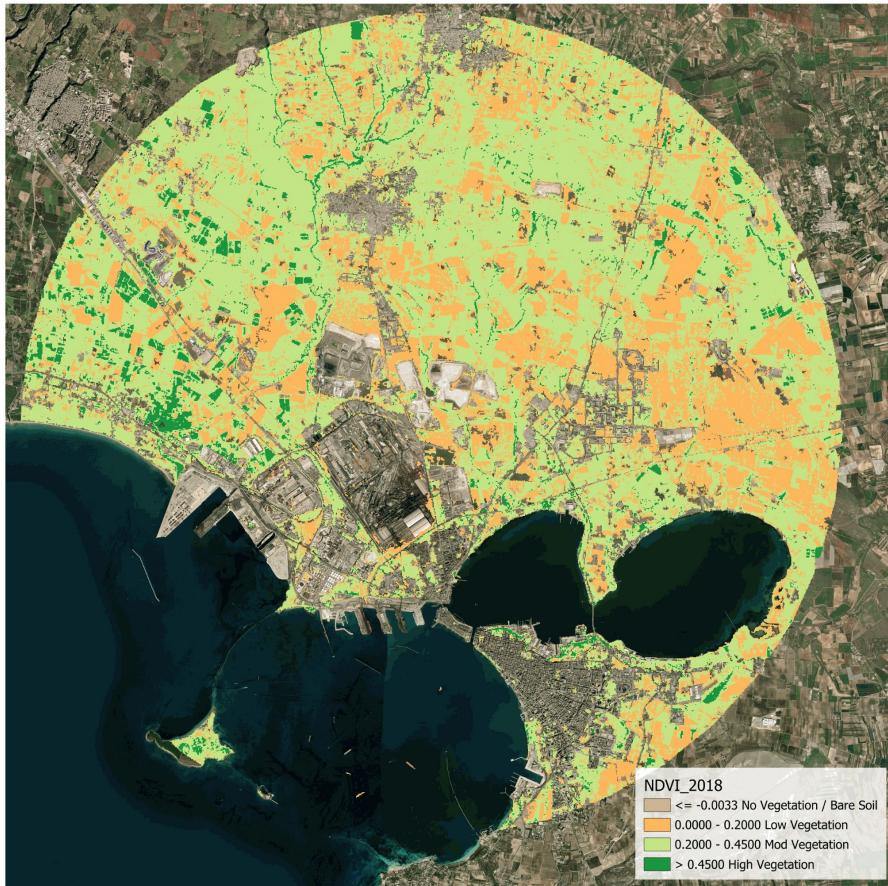


Note: It was necessary to Reclassify 113 features from Urban to Vegetation (2018) and 146 features from Urban to vegetation in order to obtain a more accurate analysis

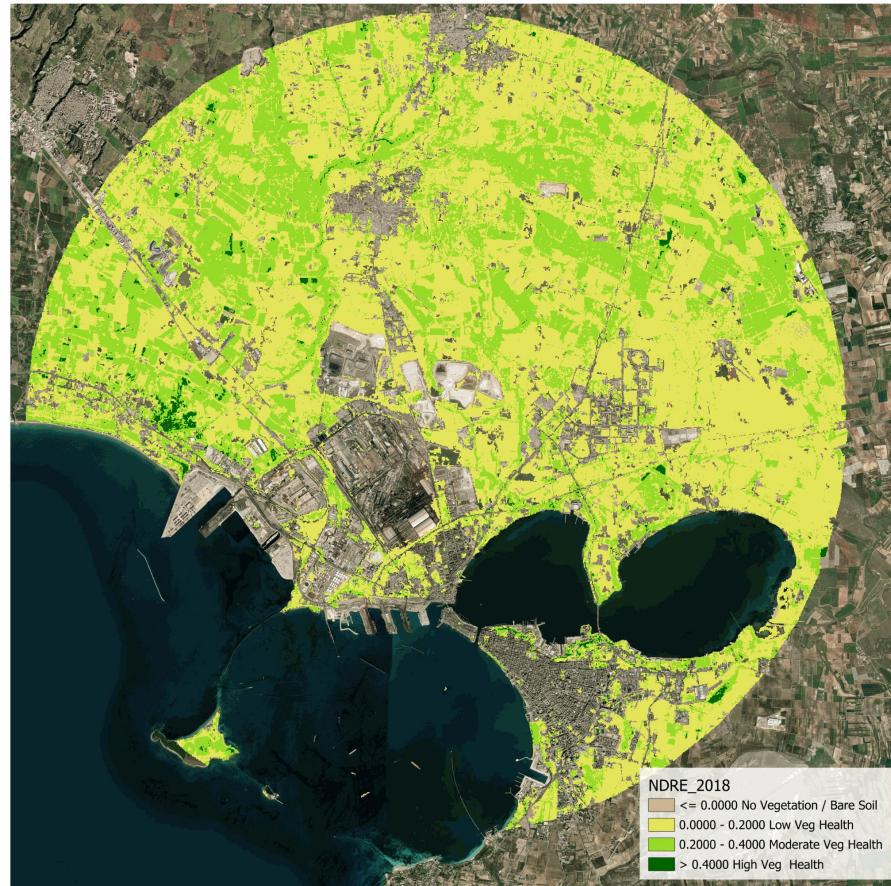


Results and Discussion

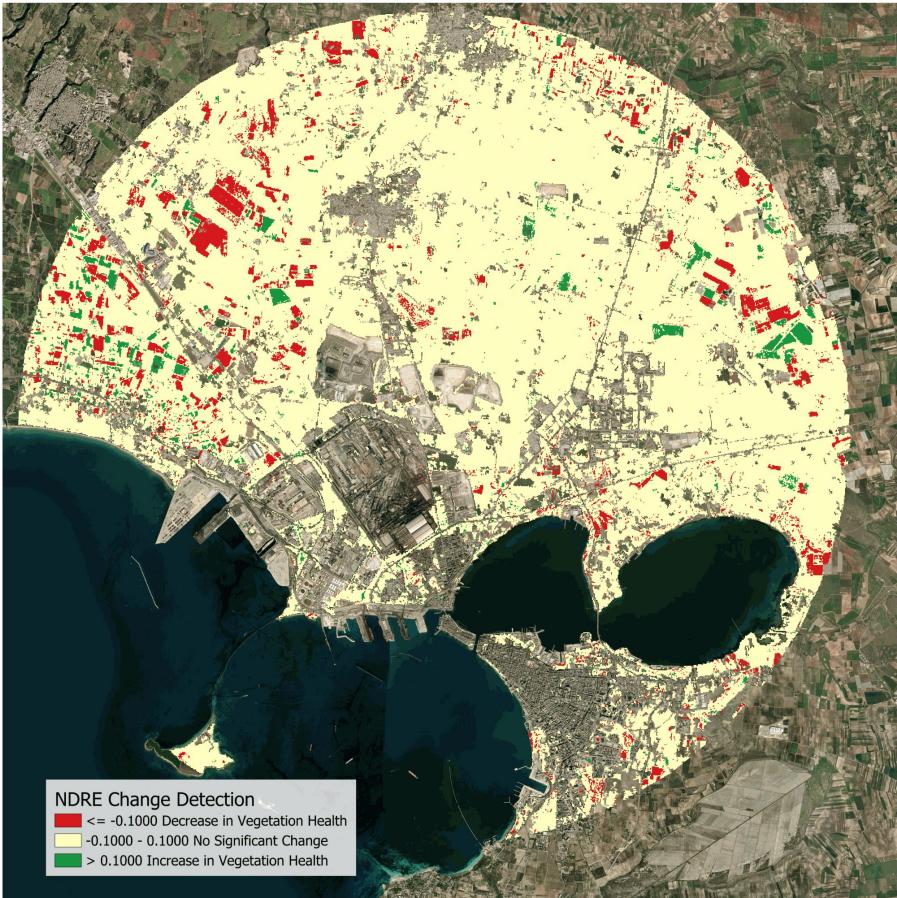
NDVI



NDRE



Change Detection

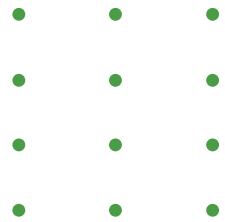


- Decrease in Vegetation Health: Both maps highlight significant areas with declining vegetation health, possibly due to industrial activity or environmental factors.
- No Significant Change: Most of the region remains stable, indicating that while reforms have prevented further degradation, they haven't led to widespread improvement.
- Increase in Vegetation Health: Both maps show small areas of improved vegetation health, suggesting localized recovery rather than a broad restoration.



Conclusion and Recommendations

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Credit: Mondadori Portfolio





Conclusion

- NDVI and NDRE indices validate each other, showing similar patterns of vegetation stress and decline around the Ilva Steel Plant.
- Most areas are stable, but significant regions show declining vegetation health, with limited improvement.
- Environmental reforms have slowed degradation but have not reversed the damage.

Recommendations

- Investigate specific pollutants and gather additional environmental data (air, water, soil, temperature).
- Conduct a time-series analysis starting from the 1990s to assess long-term vegetation health trends before and after the introduction of environmental regulations.
- Perform an urban expansion analysis to understand how industrial and urban growth might be affecting vegetation health.

References

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THANK YOU

Any Question?

