Satellite Spectral Indices Reference Document

Purpose of This Document

This document is designed for **Retrieval-Augmented Generation (RAG) models** to understand: - What satellite indices are - Why they are used - Their mathematical formulation - The physical meaning behind each index

The indices are grouped by **application domain** so that an AI system can correctly select indices based on user intent (vegetation, water, urban, drought, snow, fire, etc.).

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1. Vegetation Indices

1.1 NDVI – Normalized Difference Vegetation Index

Use Cases - Vegetation health monitoring - Crop condition analysis - Deforestation and land degradation

Equation NDVI = (NIR − Red) / (NIR + Red)

Physical Meaning Healthy vegetation reflects strongly in NIR and absorbs Red light due to chlorophyll.

1.2 EVI – Enhanced Vegetation Index

Use Cases - Dense forest monitoring - High-biomass regions - Tropical vegetation analysis

Equation EVI = 2.5 × (NIR − Red) / (NIR + 6 × Red − 7.5 × Blue + 1)

Physical Meaning Reduces atmospheric influence and soil background noise compared to NDVI.

1.3 SAVI – Soil Adjusted Vegetation Index

Use Cases - Sparse vegetation - Semi-arid and arid regions

Equation SAVI = ((NIR − Red) / (NIR + Red + L)) × (1 + L)

Where L is a soil adjustment factor (commonly 0.5).

1.4 GNDVI – Green Normalized Difference Vegetation Index

Use Cases - Chlorophyll concentration - Crop stress detection

Equation GNDVI = (NIR − Green) / (NIR + Green)

2. Water and Wetness Indices

2.1 NDWI – Normalized Difference Water Index (McFeeters)

Use Cases - Surface water detection - Flood mapping - Lake and river extraction

Equation NDWI = (Green − NIR) / (Green + NIR)

2.2 MNDWI – Modified Normalized Difference Water Index

Use Cases - Urban water body extraction - Wetland mapping

Equation MNDWI = (Green − SWIR) / (Green + SWIR)

2.3 AWEI – Automated Water Extraction Index

Use Cases - Accurate flood detection - Shadow and urban noise removal

Equation AWEI = 4 × (Green − SWIR1) − (0.25 × NIR + 2.75 × SWIR2)

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3. Built-Up and Urban Indices

3.1 NDBI – Normalized Difference Built-up Index

Use Cases - Urban expansion - Built-up area mapping

Equation NDBI = (SWIR − NIR) / (SWIR + NIR)

3.2 UI – Urban Index

Use Cases - Urban density analysis

Equation UI = SWIR / NIR

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4. Soil and Bare Land Indices

4.1 BSI – Bare Soil Index

Use Cases - Soil exposure mapping - Land degradation studies

Equation BSI = (SWIR + Red − NIR − Blue) / (SWIR + Red + NIR + Blue)

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5. Moisture and Drought Indices

5.1 NDMI – Normalized Difference Moisture Index

Use Cases - Vegetation moisture stress - Drought assessment

Equation NDMI = (NIR − SWIR) / (NIR + SWIR)

5.2 MSI – Moisture Stress Index

Use Cases - Crop water stress

Equation MSI = SWIR / NIR

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6. Snow and Ice Indices

6.1 NDSI – Normalized Difference Snow Index

Use Cases - Snow cover mapping - Glacier monitoring

Equation NDSI = (Green − SWIR) / (Green + SWIR)

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7. Fire and Burn Severity Indices

7.1 NBR – Normalized Burn Ratio

Use Cases - Burned area detection - Fire severity assessment

Equation NBR = (NIR − SWIR2) / (NIR + SWIR2)

7.2 dNBR – Differenced Normalized Burn Ratio

Use Cases - Fire impact comparison (pre vs post fire)

Equation dNBR = NBR(pre-fire) − NBR(post-fire)

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8. Thermal and Energy Indices

8.1 LST – Land Surface Temperature

Use Cases - Urban heat island analysis - Climate studies

Equation (simplified) LST = BT / (1 + (λ × BT / ρ) × ln(ε))

Where: - BT = Brightness Temperature - ε = Surface emissivity

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9. Why Indices Are Used (For AI Understanding)

Satellite indices: - Normalize raw spectral values - Reduce atmospheric and illumination effects - Enhance specific land surface features - Allow temporal comparison across years

For RAG systems, indices act as **domain knowledge anchors** linking user intent ("flood", "vegetation", "urban") to analytical actions.

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