

Package ‘GeoIndexR’

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Title Computation of Spectral and Geospatial Indices from
Multispectral Raster Data

Version 0.1.0

Description A unified, fast, and extensible framework for calculating spectral and geospatial indices from multispectral raster datasets (e.g., NDVI - Normalized Difference Vegetation Index, NDWI - Normalized Difference Water Index, MNDWI - Modified Normalized Difference Water Index, NDBI - Normalized Difference Built-up Index, SAVI - Soil Adjusted Vegetation Index, EVI - Enhanced Vegetation Index, GNDVI - Green Normalized Difference Vegetation Index, NDMI - Normalized Difference Moisture Index, BSI - Bare Soil Index). Designed around 'terra' 'SpatRaster' objects, it supports multi-band rasters, automatic band resolution, sensor presets (Sentinel-2, Landsat-8/9), customizable index parameters, vectorized computations, and comprehensive validation. Methods based on Rouse et al. (1973), McFeeters (1996) <doi:10.1080/01431169608948714>, Xu (2006) <doi:10.1080/01431160600589179>, Zha et al. (2003) <doi:10.1016/S0034-4257(03)00087-7>, Huete (1988) <doi:10.1016/0034-4257(88)90106-X>, Gitelson et al. (1996) <doi:10.1016/S0034-4257(96)00072-7>, Wilson and Sader (2002) <doi:10.1016/S0034-4257(01)00318-2>, and Rikimaru et al. (2002).

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URL <https://github.com/sowsalim01/GeoIndexR>

BugReports <https://github.com/sowsalim01/GeoIndexR/issues>

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band_mapping	<i>Sensor Band Mapping Presets</i>
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Description

Provides standard band name mappings for commonly used multispectral sensors and generic naming conventions.

Usage

```
band_mapping(
  sensor = c("generic", "sentinel2", "s2", "landsat8", "landsat9", "18", "19",
    "landsat7", "landsat5", "tm", "etm")
)
```

Arguments

sensor Character string specifying the sensor preset. Supported options:

- "generic": Common names (blue, green, red, nir, swir, swir1, swir2, rededge).
- "sentinel2" or "s2": Sentinel-2 MSI bands (B02, B03, B04, B08, B11, B12, etc.).
- "landsat8" / "landsat9" or "18" / "19": Landsat 8/9 OLI bands (B1 to B7).
- "landsat7" / "landsat5" or "etm" / "tm": Landsat 4-7 TM/ETM+ bands (B1 to B7).

Defaults to "generic".

Value

A named character vector where names represent standardized spectral band roles (e.g., "nir", "red") and values represent corresponding band or layer names for the selected sensor.

Examples

```
# Generic mapping
band_mapping("generic")

# Sentinel-2 band mapping
band_mapping("sentinel2")

# Landsat 8/9 band mapping
band_mapping("landsat8")
```

calc_arvi

Calculate Atmospherically Resistant Vegetation Index (ARVI)

Description

Computes the Atmospherically Resistant Vegetation Index (ARVI), which uses the difference between blue and red bands to reduce atmospheric aerosol effects on red reflectance.

Usage

```
calc_arvi(nir, red, blue, gamma = 1)
```

Arguments

nir	Near-infrared band (terra::SpatRaster or numeric).
red	Red band (terra::SpatRaster or numeric).
blue	Blue band (terra::SpatRaster or numeric).
gamma	Aerosol resistance coefficient. Defaults to 1.0.

Details

$$ARVI = \frac{NIR - RB}{NIR + RB}$$

where $RB = RED - \gamma \times (BLUE - RED)$.

Value

A terra::SpatRaster (named "ARVI") or numeric vector with index values.

References

Kaufman, Y. J., & Tanre, D. (1992). Atmospherically resistant vegetation index (ARVI) for EOS-MODIS. IEEE TGRS, 30(2), 261-270.

See Also

[calc_ndvi](#), [calc_evi](#), [geo_index](#)

Examples

```
calc_arvi(nir = 0.7, red = 0.2, blue = 0.1)
```

calc_awei

Calculate Automated Water Extraction Index (AWEI)

Description

Computes the Automated Water Extraction Index (AWEI) to extract surface water while suppressing shadow artifacts and dark impervious surfaces.

Usage

```
calc_awei(green, nir, swir1, swir2)
```

Arguments

green	Green band (terra::SpatRaster or numeric).
nir	Near-infrared band (terra::SpatRaster or numeric).
swir1	SWIR 1 band (terra::SpatRaster or numeric).
swir2	SWIR 2 band (terra::SpatRaster or numeric).

Details

$$AWEI = 4 \times (GREEN - SWIR1) - (0.25 \times NIR + 2.75 \times SWIR2)$$

Value

A terra::SpatRaster (named "AWEI") or numeric vector with index values.

References

Feyisa, G. L., Meilby, H., Fensholt, R., & Proud, S. R. (2014). Automated Water Extraction Index: A new technique for surface water mapping using Landsat imagery. Remote Sensing of Environment, 140, 23-35.

See Also

[calc_ndwi](#), [calc_mndwi](#), [geo_index](#)

Examples

```
calc_awei(green = 0.5, nir = 0.2, swir1 = 0.1, swir2 = 0.05)
```

calc_bsi	<i>Calculate Bare Soil Index (BSI)</i>
----------	--

Description

Computes the Bare Soil Index (BSI), combining blue, red, NIR, and SWIR bands to distinguish bare soils from vegetation and impervious land.

Usage

```
calc_bsi(swir1, red, nir, blue)
```

Arguments

swir1	Short-wave infrared 1 band (terra::SpatRaster or numeric).
red	Red band (terra::SpatRaster or numeric).
nir	Near-infrared band (terra::SpatRaster or numeric).
blue	Blue band (terra::SpatRaster or numeric).

Details

$$BSI = \frac{(SWIR1 + RED) - (NIR + BLUE)}{(SWIR1 + RED) + (NIR + BLUE)}$$

Value

A terra::SpatRaster (named "BSI") or numeric vector with index values.

References

Rikimaru, A., Roy, P. S., & Miyatake, S. (2002). Tropical forest cover density mapping. Tropical Ecology, 43(1), 39-47.

See Also

[geo_index](#)

Examples

```
calc_bsi(swir1 = 0.5, red = 0.4, nir = 0.2, blue = 0.1)
```

calc_evi	<i>Calculate Enhanced Vegetation Index (EVI)</i>
----------	--

Description

Computes the Enhanced Vegetation Index (EVI), optimizing the vegetation signal with improved sensitivity in high biomass regions and reduced atmospheric aerosol influences.

Usage

```
calc_evi(nir, red, blue, G = 2.5, C1 = 6, C2 = 7.5, L = 1)
```

Arguments

- nir Near-infrared band (terra::SpatRaster or numeric).
- red Red band (terra::SpatRaster or numeric).
- blue Blue band (terra::SpatRaster or numeric).
- G Gain factor. Defaults to 2.5.
- C1 Atmospheric resistance coefficient for red. Defaults to 6.0.
- C2 Atmospheric resistance coefficient for blue. Defaults to 7.5.
- L Canopy background adjustment. Defaults to 1.0.

Details

$$EVI = G \times \frac{NIR - RED}{NIR + C1 \times RED - C2 \times BLUE + L}$$

Description & Purpose: EVI was developed to enhance the vegetation signal in dense canopies where NDVI saturates, while reducing canopy background noise and aerosol scattering using the blue band.

Important - Reflectance Scale: EVI constants ($G = 2.5$, $C1 = 6.0$, $C2 = 7.5$, $L = 1.0$) were calibrated for physical surface reflectance in $[0, 1]$. If your input data are stored in raw integer Digital Numbers (e.g., Sentinel-2 L2A $[0, 10000]$), divide the inputs by 10000 or use `geo_index(..., scale_factor = 10000)`.

Value

A `terra::SpatRaster` (named "EVI") or numeric vector with index values.

References

Liu, H. Q., & Huete, A. (1995). A feedback based modification of the NDVI to minimize canopy background and atmospheric noise. *IEEE TGRS*, 33(2), 457-465.

See Also

[geo_index](#), [calc_ndvi](#), [calc_savi](#)

Examples

```
# Numeric example with surface reflectance values in [0, 1]
calc_evi(nir = 0.50, red = 0.20, blue = 0.10)

# Raster example
img <- get_example_data()
evi_rast <- calc_evi(nir = img[["nir"]], red = img[["red"]], blue = img[["blue"]])
print(evi_rast)
```

calc_gndvi

Calculate Green Normalized Difference Vegetation Index (GNDVI)

Description

Computes the Green Normalized Difference Vegetation Index (GNDVI) from near-infrared (nir) and green (green) bands.

Usage

```
calc_gndvi(nir, green)
```

Arguments

- nir Near-infrared band (terra::SpatRaster or numeric).
- green Green band (terra::SpatRaster or numeric).

Details

$$GNDVI = \frac{NIR - GREEN}{NIR + GREEN}$$

Description & Purpose: GNDVI is more sensitive to chlorophyll variations than standard NDVI, especially in mid-to-high biomass stages and dense crops.

Value

A terra::SpatRaster (named "GNDVI") or numeric vector with index values.

References

Gitelson, A. A., Kaufman, Y. J., & Merzlyak, M. N. (1996). Use of a green channel in remote sensing of global vegetation from EOS-MODIS. Remote Sensing of Environment, 58(3), 289-298.

See Also

[calc_ndvi](#), [geo_index](#)

Examples

```
calc_gndvi(nir = 0.8, green = 0.2)
```

calc_ibi	<i>Calculate Index-Based Built-Up Index (IBI)</i>
----------	---

Description

Computes the Index-Based Built-Up Index (IBI) by synthesizing NDBI, SAVI, and MNDWI.

Usage

```
calc_ibi(swir1, nir, red, green, L = 0.5)
```

Arguments

- swir1 Short-wave infrared 1 band (terra::SpatRaster or numeric).
- nir Near-infrared band (terra::SpatRaster or numeric).
- red Red band (terra::SpatRaster or numeric).
- green Green band (terra::SpatRaster or numeric).
- L Soil adjustment factor for internal SAVI. Defaults to 0.5.

Value

A terra::SpatRaster (named "IBI") or numeric vector with index values.

References

Xu, H. (2007). Extraction of urban built-up land features from Landsat imagery using a new index-based approach. *International Journal of Remote Sensing*, 29(14), 4267-4283.

See Also

[calc_ndbi](#), [geo_index](#)

Examples

```
calc_ibi(swir1 = 0.4, nir = 0.3, red = 0.2, green = 0.1)
```

calc_index

Dispatch and Calculate a Named Index

Description

Dynamically invokes the calculation function for any registered index by name.

Usage

```
calc_index(index, ...)
```

Arguments

index	Character string specifying index name (e.g., "NDVI", "SAVI").
...	Named band arguments (e.g., nir = ..., red = ...) and optional index parameters (such as L = 0.5).

Value

A SpatRaster or numeric vector.

Examples

```
calc_index("NDVI", nir = 0.8, red = 0.2)
calc_index("SAVI", nir = 0.8, red = 0.2, L = 0.5)
```

calc_mndwi

*Calculate Modified Normalized Difference Water Index (MNDWI)***Description**

Computes Xu's Modified Normalized Difference Water Index (MNDWI), substituting SWIR1 for NIR to enhance open water features in urban landscapes.

Usage

```
calc_mndwi(green, swir1)
```

Arguments

green	Green band (terra::SpatRaster or numeric).
swir1	Short-wave infrared 1 band (terra::SpatRaster or numeric).

Details

$$MNDWI = \frac{GREEN - SWIR1}{GREEN + SWIR1}$$

Description & Purpose: Standard NDWI can produce false water detections on built-up and impervious surfaces. MNDWI suppresses built-up noise significantly because urban land has high SWIR reflectance.

Value

A terra::SpatRaster (named "MNDWI") or numeric vector with index values.

References

Xu, H. (2006). Modification of normalised difference water index (NDWI) to enhance open water features in remotely sensed imagery. *IJRS*, 27(14), 3025-3033.

See Also

[calc_ndwi](#), [calc_awei](#), [geo_index](#)

Examples

```
calc_mndwi(green = 0.7, swir1 = 0.1)
```

calc_msavi	<i>Calculate Modified Soil Adjusted Vegetation Index 2 (MSAVI)</i>
------------	--

Description

Computes the Modified Soil Adjusted Vegetation Index 2 (MSAVI2), which eliminates the need for manually finding or specifying a soil adjustment factor L .

Usage

```
calc_msavi(nir, red)
```

Arguments

nir	Near-infrared band (terra::SpatRaster or numeric).
red	Red band (terra::SpatRaster or numeric).

Details

$$MSAVI = \frac{2 \times NIR + 1 - \sqrt{(2 \times NIR + 1)^2 - 8 \times (NIR - RED)}}{2}$$

Description & Purpose: MSAVI simplifies SAVI by calculating an inductive soil adjustment factor mathematically, providing high sensitivity in sparse vegetation without requiring empirical soil line parameters.

Value

A terra::SpatRaster (named "MSAVI") or numeric vector with index values.

References

Qi, J., Chehbouni, A., Huete, A. R., Kerr, Y. H., & Sorooshian, S. (1994). A modified soil adjusted vegetation index. *Remote Sensing of Environment*, 48(2), 119-126.

See Also

[calc_savi](#), [calc_osavi](#), [geo_index](#)

Examples

```
# Numeric scalar calculation
calc_msavi(nir = 0.7, red = 0.2)

# Raster layer calculation
img <- get_example_data()
msavi_rast <- calc_msavi(nir = img[["nir"]], red = img[["red"]])
print(msavi_rast)
```

`calc_msi`*Calculate Moisture Stress Index (MSI)*

Description

Computes the Moisture Stress Index (MSI) from SWIR1 and NIR bands.

Usage

```
calc_msi(swir1, nir)
```

Arguments

<code>swir1</code>	Short-wave infrared 1 band (terra::SpatRaster or numeric).
<code>nir</code>	Near-infrared band (terra::SpatRaster or numeric).

Details

$$MSI = \frac{SWIR1}{NIR}$$

Value

A terra::SpatRaster (named "MSI") or numeric vector with index values.

References

Rock, B. N., Vogelmann, J. E., Williams, D. L., & Vogelmann, A. F. (1986). Remote detection of forest damage. *BioScience*, 36(7), 439-445.

See Also

[calc_ndmi](#), [geo_index](#)

Examples

```
calc_msi(swir1 = 0.4, nir = 0.8)
```

`calc_ndbi`*Calculate Normalized Difference Built-up Index (NDBI)*

Description

Computes the Normalized Difference Built-up Index (NDBI) for mapping urban and impervious surfaces.

Usage

```
calc_ndbi(swir1, nir)
```

Arguments

<code>swir1</code>	Short-wave infrared 1 band (terra::SpatRaster or numeric).
<code>nir</code>	Near-infrared band (terra::SpatRaster or numeric).

Details

$$NDBI = \frac{SWIR1 - NIR}{SWIR1 + NIR}$$

Value

A terra::SpatRaster (named "NDBI") or numeric vector with index values.

References

Zha, Y., Gao, J., & Ni, S. (2003). Use of normalized difference built-up index in automatically mapping urban areas from TM imagery. *IJRS*, 24(3), 583-594.

See Also

[calc_ibi](#), [geo_index](#)

Examples

```
calc_ndbi(swir1 = 0.6, nir = 0.3)
```

`calc_ndmi`*Calculate Normalized Difference Moisture Index (NDMI)*

Description

Computes the Normalized Difference Moisture Index (NDMI) to assess vegetation canopy liquid water content.

Usage

```
calc_ndmi(nir, swir1)
```

Arguments

<code>nir</code>	Near-infrared band (terra::SpatRaster or numeric).
<code>swir1</code>	Short-wave infrared 1 band (terra::SpatRaster or numeric).

Details

$$NDMI = \frac{NIR - SWIR1}{NIR + SWIR1}$$

Value

A terra::SpatRaster (named "NDMI") or numeric vector with index values.

References

Gao, B. C. (1996). NDWI—A normalized difference water index for remote sensing of vegetation liquid water from space. *Remote Sensing of Environment*, 58(3), 257-266.

See Also

[calc_msi](#), [geo_index](#)

Examples

```
calc_ndmi(nir = 0.7, swir1 = 0.3)
```

calc_ndsi*Calculate Normalized Difference Snow Index (NDSI)*

Description

Computes the Normalized Difference Snow Index (NDSI) for mapping snow and ice cover.

Usage

```
calc_ndsi(green, swir1)
```

Arguments

green	Green band (terra::SpatRaster or numeric).
swir1	Short-wave infrared 1 band (terra::SpatRaster or numeric).

Details

$$NDSI = \frac{GREEN - SWIR1}{GREEN + SWIR1}$$

Value

A terra::SpatRaster (named "NDSI") or numeric vector with index values.

References

Hall, D. K., Riggs, G. A., & Salomonson, V. V. (1995). Development of methods for mapping global snow cover using moderate resolution imaging spectroradiometer data. Remote Sensing of Environment, 54(2), 127-140.

See Also

[geo_index](#)

Examples

```
calc_ndsi(green = 0.8, swir1 = 0.2)
```

calc_ndvi

*Calculate Normalized Difference Vegetation Index (NDVI)***Description**

Computes the Normalized Difference Vegetation Index (NDVI) directly from near-infrared (nir) and red (red) bands or numeric vectors.

Usage

```
calc_ndvi(nir, red)
```

Arguments

nir	Near-infrared band (terra::SpatRaster or numeric vector/matrix).
red	Red band (terra::SpatRaster or numeric vector/matrix).

Details

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

Description & Purpose: NDVI is the most widely used remote sensing index for monitoring vegetation greenness, photosynthetic activity, and canopy vigor. Chlorophyll pigments in green leaves absorb red light strongly, while the spongy mesophyll structure scatters near-infrared light.

Direct Band Usage vs geo_index(): While [geo_index\(image, "NDVI"\)](#) handles multi-band raster extraction and band mapping automatically, `calc_ndvi()` is a direct, lower-level computation function that works on:

- Individual single-layer terra::SpatRaster objects (e.g. `nir = img[["nir"]]`, `red = img[["red"]]`).
- Standard R numeric vectors, scalars, or matrices.

Value Range & Interpretation:

- **0.6 to 0.9:** Dense, healthy green vegetation (forests, mature crops).
- **0.2 to 0.5:** Moderate to sparse vegetation (grasslands, shrublands, young crops).
- **0.0 to 0.1:** Bare soil, rock, sand, impervious urban areas.
- **< 0.0:** Water bodies, snow, ice, and clouds.

Value

A single-layer terra::SpatRaster (with layer name "NDVI") or a numeric vector matching input dimensions.

References

Rouse, J. W., Haas, R. H., Schell, J. A., & Deering, D. W. (1974). Monitoring the vernal advancement and retrogradation (Green wave effect) of natural vegetation. NASA/GSFC Type III Final Report, Greenbelt, MD.

See Also

[geo_index](#), [calc_savi](#), [calc_evi](#), [index_registry](#)

Examples

```
library(terra)

# --- Example 1: Direct calculation on numeric values ---
calc_ndvi(nir = 0.8, red = 0.2)

# Vectorized computation on numeric vectors:
nirs <- c(0.8, 0.5, 0.1, 0.02)
reds <- c(0.1, 0.3, 0.1, 0.05)
calc_ndvi(nir = nirs, red = reds)

# --- Example 2: Calculation on extracted SpatRaster layers ---
img <- get_example_data()
ndvi_rast <- calc_ndvi(nir = img[["nir"]], red = img[["red"]])
print(ndvi_rast)
```

calc_ndwi	<i>Calculate Normalized Difference Water Index (NDWI)</i>
-----------	---

Description

Computes McFeeters' Normalized Difference Water Index (NDWI) for delineating open water bodies.

Usage

```
calc_ndwi(green, nir)
```

Arguments

- green Green band (terra::SpatRaster or numeric).
- nir Near-infrared band (terra::SpatRaster or numeric).

Details

$$NDWI = \frac{GREEN - NIR}{GREEN + NIR}$$

Description & Purpose: NDWI maximizes the reflectance of water in the green wavelength while minimizing the low reflectance of water in the NIR wavelength.

Interpretation:

- **> 0.0:** Water surfaces (rivers, lakes, wetlands, reservoirs).
- **<= 0.0:** Non-water surfaces (vegetation, soil, built-up areas).

Value

A terra::SpatRaster (named "NDWI") or numeric vector with index values.

References

McFeeters, S. K. (1996). The use of the Normalized Difference Water Index (NDWI) in the delineation of open water features. *International Journal of Remote Sensing*, 17(7), 1425-1432.

See Also

[calc_mndwi](#), [calc_awei](#), [geo_index](#)

Examples

```
calc_ndwi(green = 0.6, nir = 0.2)

img <- get_example_data()
ndwi_rast <- calc_ndwi(green = img[["green"]], nir = img[["nir"]])
print(ndwi_rast)
```

calc_osavi

Calculate Optimized Soil-Adjusted Vegetation Index (OSAVI)

Description

Computes the Optimized Soil-Adjusted Vegetation Index (OSAVI) with a standard optimal adjustment parameter $\theta = 0.16$.

Usage

```
calc_osavi(nir, red, theta = 0.16)
```

Arguments

nir	Near-infrared band (terra::SpatRaster or numeric).
red	Red band (terra::SpatRaster or numeric).
theta	Canopy background adjustment factor. Defaults to 0.16.

Details

$$OSAVI = \frac{NIR - RED}{NIR + RED + \theta} \times (1 + \theta)$$

Description & Purpose: OSAVI is an optimization of SAVI that fixes theta = 0.16, which was found to provide optimal suppression of soil background variation across a broad range of agricultural canopies.

Value

A terra::SpatRaster (named "OSAVI") or numeric vector with index values.

References

Rondeaux, G., Steven, M., & Baret, F. (1996). Optimization of soil-adjusted vegetation indices. Remote Sensing of Environment, 55(2), 95-107.

See Also

[calc_savi](#), [calc_msavi](#), [geo_index](#)

Examples

```
calc_osavi(nir = 0.7, red = 0.2)

img <- get_example_data()
osavi_rast <- calc_osavi(nir = img[["nir"]], red = img[["red"]])
print(osavi_rast)
```

calc_savi

Calculate Soil Adjusted Vegetation Index (SAVI)

Description

Computes the Soil Adjusted Vegetation Index (SAVI) to minimize soil brightness and background influences, using a canopy background adjustment factor L.

Usage

```
calc_savi(nir, red, L = 0.5)
```

Arguments

nir	Near-infrared band (terra::SpatRaster or numeric).
red	Red band (terra::SpatRaster or numeric).
L	Soil adjustment factor. Defaults to 0.5.

Details

$$SAVI = \frac{NIR - RED}{NIR + RED + L} \times (1 + L)$$

Description & Purpose: In arid, semi-arid, or sparsely vegetated regions, exposed soil background alters red and NIR reflectance, distorting standard vegetation indices like NDVI. SAVI introduces a soil line calibration constant L that stabilizes the index.

Parameter L:

- L = 0.5 (default): Optimal for intermediate to moderate vegetation cover.
- L = 1.0: Recommended for very low / sparse vegetation cover.
- L = 0.25: Recommended for higher vegetation densities.
- When L = 0, SAVI is mathematically identical to NDVI.

Value

A terra::SpatRaster (named "SAVI") or numeric vector with index values.

References

Huete, A. R. (1988). A soil-adjusted vegetation index (SAVI). Remote Sensing of Environment, 25(3), 295-309.

See Also

[geo_index](#), [calc_osavi](#), [calc_msavi](#), [calc_ndvi](#)

Examples

```
# Numeric scalar calculation
calc_savi(nir = 0.7, red = 0.2, L = 0.5)

# Raster layer calculation
img <- get_example_data()
savi_rast <- calc_savi(nir = img[["nir"]], red = img[["red"]], L = 0.5)
print(savi_rast)
```

geo_index

*Compute a Spectral Index from Multispectral Raster Data***Description**

Calculates a specified spectral or geospatial index from a `terra::SpatRaster` object or a raster file path. Band names are automatically resolved using heuristic matching, sensor presets, or explicit user mapping.

Usage

```
geo_index(image, index, bands = NULL, scale_factor = NULL, sensor = NULL, ...)
```

Arguments

<code>image</code>	A <code>terra::SpatRaster</code> object or a character string specifying the file path to a raster image on disk.
<code>index</code>	Character string specifying the index to compute (case-insensitive, e.g., "NDVI", "SAVI", "EVI", "NDWI", etc.). See list_indices or index_registry for supported indices.
<code>bands</code>	Optional named vector or list specifying custom band mapping (e.g., <code>c(nir = "B08", red = "B04")</code> or <code>c(nir = 4, red = 3)</code>).
<code>scale_factor</code>	Optional numeric scaling divisor (e.g., 10000 for Sentinel-2 L2A or Landsat surface reflectance) to convert integer Digital Numbers into physical reflectance [0, 1].
<code>sensor</code>	Optional character string specifying a sensor preset for automatic band name resolution (e.g., "sentinel2", "landsat8", "landsat9").
<code>...</code>	Additional parameters passed to the index calculation function (e.g., soil adjustment factor L for SAVI, or gain factor G for EVI).

Value

A single-layer `terra::SpatRaster` object containing the computed index values, with layer name set to the uppercase index code, preserving all original spatial properties (CRS, resolution, extent, dimensions).

Examples

```
img <- get_example_data()

# 1. Compute NDVI
ndvi <- geo_index(img, "NDVI")
print(ndvi)

# 2. Compute SAVI with custom parameter
savi <- geo_index(img, "SAVI", L = 0.5)
```

```
# 3. Compute EVI with scale factor for raw DN values
evi <- geo_index(img, "EVI", scale_factor = 1)
```

geo_index_all

Compute All Eligible Spectral Indices Automatically

Description

Automatically detects which spectral indices can be computed given the available bands in a `terra::SpatRaster` image (or raster file path) and calculates all of them.

Usage

```
geo_index_all(
  image,
  bands = NULL,
  scale_factor = NULL,
  sensor = NULL,
  quiet = FALSE,
  ...
)
```

Arguments

<code>image</code>	A <code>terra::SpatRaster</code> object or raster file path containing multispectral bands.
<code>bands</code>	Optional named vector or list specifying custom band mapping.
<code>scale_factor</code>	Optional numeric scaling divisor (e.g. 10000).
<code>sensor</code>	Optional character string specifying a sensor preset.
<code>quiet</code>	Logical. If FALSE (default), outputs an informative message listing which indices were detected and computed.
<code>...</code>	Additional parameters passed to index calculation functions.

Value

A multi-layer `terra::SpatRaster` containing all computable indices as individual layers.

Examples

```
img <- get_example_data()

# Compute all supported indices compatible with img bands
all_idx <- geo_index_all(img)
names(all_idx)
```

geo_index_custom	<i>Compute a Custom Spectral or Geospatial Index</i>
------------------	--

Description

Computes a custom spectral or geospatial index from a raster image or numeric inputs using a user-defined mathematical formula. The formula is securely parsed, validated against an AST whitelist of safe mathematical functions and operators, and evaluated vectorially with terra.

Usage

```
geo_index_custom(
  image,
  formula,
  bands = NULL,
  params = list(),
  name = "CustomIndex",
  scale_factor = NULL,
  denominator_tolerance = 1e-06,
  sensor = NULL,
  ...
)
```

Arguments

image	A terra::SpatRaster object or a character string specifying the file path to a raster image on disk.
formula	Character string specifying the mathematical expression to compute (e.g., "(nir - red) / (nir + red)" or "G * (nir - red) / (nir + C1 * red - C2 * blue + L)").
bands	Optional named vector or list specifying custom band mapping (e.g., c(nir = 4, red = 3) or c(nir = "B08", red = "B04")).
params	Optional named list of numeric parameter constants used in the formula (e.g., list(G = 2.5, C1 = 6.0, C2 = 7.5, L = 1.0)).
name	Character string specifying the name of the output index layer. Defaults to "CustomIndex".
scale_factor	Optional numeric scaling divisor (e.g., 10000 for Sentinel-2 or Landsat surface reflectance products) applied to input bands before evaluating the formula.
denominator_tolerance	Numeric threshold for near-zero denominators. Divisions where the absolute denominator is smaller than this value are safely converted to NA. Defaults to 1e-6.
sensor	Optional character string specifying a sensor preset for automatic band name resolution (e.g., "sentinel2", "landsat8").
...	Additional named numeric constants passed directly to the formula evaluation.

Value

A single-layer terra::SpatRaster (or numeric object) containing the computed custom index values, preserving all original spatial properties.

Examples

```
img <- get_example_data()

# 1. Simple custom ratio index
custom_ratio <- geo_index_custom(
  img,
  formula = "(nir - red) / (nir + red)",
  bands = c(red = "red", nir = "nir"),
  name = "CustomNDVI"
)
print(custom_ratio)

# 2. Custom parameterized index
custom_evi <- geo_index_custom(
  img,
  formula = "G * (nir - red) / (nir + C1 * red - C2 * blue + L)",
  bands = c(blue = "blue", red = "red", nir = "nir"),
  params = list(G = 2.5, C1 = 6.0, C2 = 7.5, L = 1.0),
  name = "CustomEVI"
)
print(custom_evi)
```

 geo_indices

Compute Multiple Spectral Indices from Multispectral Raster Data

Description

Computes a collection of spectral indices from a multispectral terra::SpatRaster or raster file path and returns the results stacked into a multi-layer SpatRaster.

Usage

```
geo_indices(
  image,
  indices,
  bands = NULL,
  scale_factor = NULL,
  sensor = NULL,
  ...
)
```

Arguments

image	A terra::SpatRaster object or file path containing multispectral bands.
indices	Character vector of index codes to compute (e.g., c("NDVI", "NDWI", "NDBI", "NDMI")).
bands	Optional named vector or list specifying custom band mapping.
scale_factor	Optional numeric scaling divisor (e.g. 10000).
sensor	Optional character string specifying a sensor preset.
...	Additional parameters passed to index calculation functions.

Value

A multi-layer terra::SpatRaster where each layer corresponds to one computed index, named accordingly.

Examples

```
img <- get_example_data()

# Compute NDVI, NDWI and MNDWI simultaneously
stack <- geo_indices(img, c("NDVI", "NDWI", "MNDWI"))
print(stack)
names(stack)
```

get_example_data

Get Example Multispectral SpatRaster

Description

Returns a ready-to-use synthetic 6-band terra::SpatRaster for fast, reproducible examples and unit testing without downloading satellite scenes.

Usage

```
get_example_data()
```

Details

The raster is generated programmatically (10 x 10 pixels, 100 m x 100 m extent, EPSG:32631). It contains three simulated land-cover types: healthy vegetation (pixels 2-40), water (pixels 41-70), and built-up / bare soil (pixels 71-100). Pixel 1 is NA in all bands for boundary / NA-handling verification.

Spectral bands (reflectance 0-1):

- blue: Blue (0.45 - 0.51 um)
- green: Green (0.53 - 0.59 um)

- red: Red (0.64 - 0.67 μm)
- nir: Near-infrared (0.85 - 0.88 μm)
- swir1: Short-wave infrared 1 (1.57 - 1.65 μm)
- swir2: Short-wave infrared 2 (2.11 - 2.29 μm)

Value

A `terra::SpatRaster` with 6 layers named "blue", "green", "red", "nir", "swir1", "swir2".

Examples

```
img <- get_example_data()
print(img)
terra::nlyr(img)
```

index_registry

Central Registry of Spectral and Geospatial Indices

Description

Retrieves metadata for all built-in spectral indices or a specific index by name or category. Metadata includes mathematical formulas, required spectral bands, parameter defaults, purpose, interpretation guidelines, limitations, scale sensitivity, and scientific literature references.

Usage

```
index_registry(category = NULL)
```

Arguments

category Optional character string to filter indices by category (e.g., "vegetation", "water", "urban", "soil", "moisture", "snow").

Value

A `data.frame` containing the registry of supported indices and their metadata.

Examples

```
# View all indices
reg <- index_registry()
reg[, c("index", "name", "category")]

# View vegetation indices only
veg_reg <- index_registry(category = "vegetation")
veg_reg$index
```

index_summary	<i>Summary Statistics for Spectral Indices</i>
---------------	--

Description

Computes descriptive statistics for one or multiple spectral index layers in a `terra::SpatRaster` object, including min, max, mean, median, standard deviation, percentiles (5th, 25th, 75th, 95th), and NA percentage.

Usage

```
index_summary(x, digits = 4)
```

Arguments

x	A <code>terra::SpatRaster</code> object containing one or more index layers.
digits	Integer indicating the number of decimal places to round results. Defaults to 4.

Value

A data.frame of class "geo_index_summary" with one row per layer:

index	Layer/index name.
min	Minimum index value.
max	Maximum index value.
mean	Mean index value.
median	Median index value.
sd	Standard deviation.
q05	5th percentile.
q25	25th percentile (1st quartile).
q75	75th percentile (3rd quartile).
q95	95th percentile.
na_pct	Percentage of NA values (0 to 100).
total_cells	Total number of raster cells.

Examples

```
img <- get_example_data()
ndvi <- geo_index(img, "NDVI")
index_summary(ndvi)

# Multi-layer summary
stack <- geo_indices(img, c("NDVI", "NDWI", "NDBI"))
index_summary(stack)
```

list_indices	<i>List Supported Spectral Index Codes</i>
--------------	--

Description

List Supported Spectral Index Codes

Usage

```
list_indices(category = NULL)
```

Arguments

category Optional character string to filter by category.

Value

A character vector of index codes.

Examples

```
list_indices()
list_indices("vegetation")
```

plot_index	<i>Visualize a Spectral Index with Thematic Color Palettes</i>
------------	--

Description

Plots a single-layer or selected layer from a `terra::SpatRaster` index object using tailored color palettes designed for vegetation, water, soil, urban, and custom analysis.

Usage

```
plot_index(x, index = NULL, main = NULL, col = NULL, ...)
```

Arguments

x	A <code>terra::SpatRaster</code> object containing index values.
index	Optional character string specifying which layer to plot if x contains multiple layers.
main	Optional plot title. Defaults to the layer name.
col	Optional color palette. If NULL (default), an appropriate palette is automatically chosen based on the index category or a perceptual palette for custom indices.
...	Additional graphical arguments passed to <code>terra::plot</code> .

Value

Invisible terra::SpatRaster object that was plotted.

Examples

```
img <- get_example_data()
ndvi <- geo_index(img, "NDVI")
plot_index(ndvi)
```

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