Supplementary Material for

Recent Applications of Landsat 8/OLI and Sentinel-2/MSI for Land Use and Land Cover Mapping: A Systematic Review

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This supporting information file includes formulas and references for vegetation indices that can be derived from Landsat 8/Operational Land Imager and Sentinel-2/MultiSpectral Instrument data. Supplementary Table 1 presented conventional vegetation indices cited in the main text as the mostly applied ones in remote sensing-based studies. Supplementary Table 2 details formulas and references of less frequent vegetation indices cited in the main text as input for LULC mapping. Supplementary Table 3 includes other less frequent vegetation indices that can be further explored considering their characteristics and results from papers not included in the systematic review.

For more details, please see the references for each vegetation index and the papers of the main paper that have explored them. We are working on studies for applying these VIs to improve LULC classification and LULCC detection in Brazil.

Supplementary Table 1. Conventional vegetation indices cited in the systematic review.

Spectral Vegetation Indices*	Equation for L8 bands	Equation for S2 bands
EVI	2.5*(b5 − b4)/(b5 + 6*b4 − 7.5*b2 + 1)	2.5*(b8 − b4)/(b8 + 6*b4 − 7.5*b2 + 1)
NDVI	(b5 – b4)/(b5 + b4)	(b8 – b4)/(b8 + b4)
NDWI (Gao)	(b5 – b6)/(b5 + b6)	(b8 – b11)/(b8 + b11)
NDWI (McFeeters)	(b3 – b5)/(b3 + b5)	(b3 – b8)/(b3 + b8)
SAVI	((b8 – b4))/((b8 + b4 + 0.5))*1.5	((b8 – b4))/((b8 + b4 + 0.5))*1.5
Derived Vis		
EVI-2	2.5*(b5 − b4)/(b5 + 6*b4 + 2.4*b2 + 1)	2.5*(b8 − b4)/(b8 + 6*b4 + 2.4*b2 + 1)
GNDVI	(b5 – b3)/(b5 + b3)	(b8 – b3)/(b8 + b3)
MSAVI	-	$2*b8 + 1 - \sqrt{(2*b8 + 1)^2 - 8*(b8 – b5)}/2$
OSAVI	1.16*b5 – b4/b5 + b4 + 0.16	1.16*b8 – b4/b8 + b4 + 0.16

***Description:**

EVI = Enhanced Vegetation Index (Huete et al., 2002).

NDVI = Normalized Difference Vegetation Index (Rouse Jr. et al., 1974).

NDWI (Gao) = Normalized Difference Vegetation Index (Gao, 1996).

NDWI (McFeeters) = Normalized Difference Vegetation Index (McFeeters, 1996).

SAVI = Soil-Adjusted Vegetation Index (Huete, 1988).

EVI-2 = Enhanced Vegetation Index-2 (Jiang et al., 2008).

GNDVI = Green Normalized Difference Vegetation Index (Gitelson, Kaufman, and Merzlyak, 1996).

MSAVI = Modified Soil-Adjusted Vegetation Index (Qi et al., 1994).

OSAVI = Optimized Soil-Adjusted Vegetation Index (Rondeaux, Steven, and Baret, 1996).

Suplementary Table 2. Less frequent vegetation indices cited in the systematic review as input for LULC mapping.

Spectral Vegetation Indices*	Equation for L8 bands	Equation for S2 bands
AFRI1.6	-	b8a - 0.66 * b11/b8a + 0.66 * b11
ARI	-	(1/b3) - (1/b5)
AVI	-	2*b8a - b4
BAI or BAIS2	-	(1 -√b6*b7*b8a/b4)*(b12 - b8a/√b12 + b8a + 1)
CI_{GREEN}	b5/b3 – 1	b8/b3 - 1
CI_{RE}	-	((b7/b5) - 1)
$CI_{RED\&RE}$	-	(b8/a*b4 + (1 - a)*b5) – 1 a: between 0 and 1
CMRI	(NDVI - NDWI)	(NDVI - NDWI)
CRI700	-	1/b2 – 1/b5
CVI	b5*b4/(b3)²	b8*b4/(b3)²
Datt1	-	(b8 - b5)/(b8 - b4)
Datt3	-	b8a/b3*b5
DBI	b2 - b10/b2 + b10 - NDVI	-
DBSI	b6 - b3/b6 + b3 – NDVI	b11 - b3/b11 + b3 – NDVI
DNVI	(b1 - b2)²/ √b1 + b2	(b1 - b2)²/ √b1 + b2
GARI	b5 - [b3 - (b2 - b4)]/b5 + [b3 - (b2 - b4)]	b8 - [b3 - (b2 - b4)]/b8 + [b3 - (b2 - b4)]
GCVI	(b5/b3) – 1	(b8/b3) – 1
GEMI	*n*(1 - 0.25**n*) – b4 - 0.125/1 - b4 factor *n*: 2(b8² - b4²) + 1.5*b8 + 0.5*b4/b8+b4+0.5	*n*(1 - 0.25**n*) – b4 - 0.125/1 - b4 factor *n*: 2(b8² - b4²) + 1.5*b8 + 0.5*b4/b8+b4+0.5
IBI	NDBI – (NDVI + MNDWI/2)/NDBI + (NDVI + MNDWI/2)	NDBI – (NDVI + MNDWI/2)/NDBI + (NDVI + MNDWI/2)
IRECI	-	(b7 – b4)/(b5/b6)
LSWI	(b5 – b6)/(b5 + b6)	(b8 – b11)/(b8 + b11)
Maccioni	-	(b7 - b5)/(b7 - b4)
MIRBI	10*b7 - 9.8*b6 + 2	10*b12 - 9.8*b11 + 2
MMRI	|MNDWI|-|NDVI|/|MNDWI|+|NDVI|	|MNDWI|-|NDVI|/|MNDWI|+|NDVI|
MNDBI	b7 - b8/b7 + b8	(b12 - b8)/(b12 + b8)
MNDSI	b7 - b8/b7 + b8	-
MNDVI	b5 - b4/b5 + b4 - 2*b2	b8 - b4/b8 + b4 - 2*b2
MNDWI	(b3 - b6)/(b3 + b6)	(b3 - b11)/(b3 + b11)
MNSI	-	0.404*b3 + 0.039*b4 - 0.505*b6 + 0.762*b8
MSR	-	b8/b4 - 1/√b8/b5 + 1
$MSR_{RED\&RE}$	-	b8/(a*b4 +(1 - a)*b5)-1/√b8(a*b4 +(1 - a)*b5) + 1 where a = between 0 and 1
MSR_{RE}	-	((b8/b5) − 1)/(√((b8/b5) + 1))
MSR_{REn}	-	((b8a/b5) −1)/(√((b8a/b5) +1))
NBR	(b5 − b7)/(b5 + b7)	(b8 – b12)/(b8 + b12)
NBR-2	((b6 – b7))/((b6 + b7))	((b11 – b12))/((b11 + b12))
NDBaI	-	(b6 - b11)/(b6 + b11)
NDBI	(b6 – b5)/(b6 + b5)	(b11 – b8)/(b11 + b8)
NDFI	GV_{Shade} – (NPV + Soil)/GV_{Shade} + (NPV + Soil), where Soil, Shade, Green Vegetation (GV), and Non-	GV_{Shade} – (NPV + Soil)/GV_{Shade} + (NPV + Soil), where Soil, Shade, Green Vegetation (GV), and Non-

	Photosynthetic Vegetation (NPV) are defined using a linear mixture model	Photosynthetic Vegetation (NPV) are defined using a linear mixture model
NDII	(b5 – b6)/(b5 + b6)	(b8 – b11)/(b8 + b11)
NDMI	(b5 – b6)/(b5 + b6)	(b8 - b11)/(b8 + b11)
NDTI	((b6 – b7))/((b6 + b7))	((b11 – b12))/((b11 + b12))
$NDVI_{RE}$	-	(b8 – b5)/(b8 + b5)
$NDVI_{RE1n}$	-	(b8a - b5)/(b8a + b5)
$NDVI_{RE}2$	-	(b8 - b6)/(b8 + b6)
$NDVI_{RE2n}$	-	(b8a - b6)/(b8a + b6)
NGRDI	-	(b3 - b5)/(b3 + b5)
NRUI	RUI – MNDSI/RUI + MNDSI, where RUI is the Ratio Urban Index	RUI – MNDSI/RUI + MNDSI, where RUI is the Ratio Urban Index
PPR	(b3 - b2)/(b3 + b2)	(b3 - b2)/(b3 + b2)
PSRI	-	(b4 – b3)/b6
PVR	(b3 - b4)/(b3 + b4)	(b3 - b4)/(b3 + b4)
RedSWIR1	b4 – b6	b4 - b11
REIP	-	700 + 40*((b4 + b7/2) - b5/b6 - b5)
RERVI	-	b8/b5
$RTVI_{core}$	-	100*(b8 – b5) - 10*(b8 – b3)
$SAVI_{R\&RE}$	-	(1 + L)(b8 - (ab4 +(1 - a)b5))/b5 + L+ (ab4 + (1 - a)*b5)
SIPI	b3/b5 - b4	b3/b8 - b4
SIWSI	-	(b8a - b11)/(b8a + b11)
SRI	b5/b4	b8/b4
$SR_{NIRnarrowGreen}$	-	b8a/b3
$SR_{NIRnarrowRed}$	-	b8a/b4
STI	b5/b6	b11/b12
$SWIR_{Index}$	b6 - b8/a	b11 - b8/a where a = number of clear observations
S2REP	-	700 + 35*((((b7 – b4/2) – b5)/b6-b5))
TVI	-	0.5 * (120 * (b6 – b3) – 200 * (b4 – b3))
$VARI_{GREEN}$	(b3 – b4)/(b3 + b4 – b2)	(b3 - b4)/(b3 + b4 - b2)
VSDI	1 - [(b6 - b2)+(b4 - b2)]	1 - [(b11 - b2)+(b4 - b2)]

***Description:**

AFRI1.6 = Aerosol Free Vegetation Index 1.6 (Karnieli, Kaufman, Remer, and Wald, 2001).

ARI = Anthocyanin Reflectance Index (Gitelson, Chivkunova and Merzlyak, 2009).

AVI = Ashburn Vegetation Index (Ashburn, 1978).

BAI ou BAIS2 = Burned Area Index for Sentinel-2 (Filipponi, 2018).

CI_{GREEN} = Chlorophyll Index Green (Gitelson et al., 2003a).

CI_{RE} = Chlorophyll Index Red-edge (Gitelson et al., 2003a).

$CI_{RED\&RE}$ = Red and red-edge modified Chlorophyll Index ((Xie et al. 2018).

CMRI = Combined Mangrove Recognition Index (Gupta et al., 2018).

CRI700 = Carotenoid Reflectance Index 700 (Gitelson, Merzlyak, and Chivkunova, 2001a).

CVI = Chlorophyll Vegetation Index (Hunt et al., 2011).

Datt1 = Vegetation Index proposed by Datt (Datt, 1999a).

Datt3 = Vegetation Index proposed by Datt (Datt, 1998).

DBI = Dry Built-up Index (Rasul et al., 2018).

DBSI = Dry Bare-Soil Index (Rasul et al., 2018).

DNVI = Discriminant Normalized Vegetation Index (Manna and Raychawdhuri, 2018).

GARI = Green atmospherically resistant vegetation index (Gitelson, Kaufman and Merzlyak, 1996).

GCVI = Green Chlorophyll Vegetation Index (Gitelson et al., 2003b).

GEMI = Global Environment Monitoring Index (Pinty and Verstraete, 1992).

IBI = Index-based Built-up Index (Xu, 2008).

IRECI = Inverted Red-edge (Frampton et al., 2013).

LSWI = Land Surface Water Index (Xiao et al., 2002).

Maccioni = Vegetation Index proposed by Maccioni (Maccioni, Agati, and Mazzinghi, 2001).

MIRBI = Mid Infrared Burned Index (Trigg and Flasse, 2001).

MMRI = Modular Mangrove Recognition Index (Diniz et al., 2019).

MNDBI = Modified Normalized Difference Built-up Index (Shingare, Hemane, and Dandekar, 2014).

MNDSI = Modified Normalized Difference Soil Index (Piyoosh and Gosh, 2018).

MNDVI = Modified Normalized Difference Vegetation Index (Main et al., 2011).

MNDWI = Modified Normalized Difference Water Index (Xu, 2006).

MNSI = Misra Non-such Index (Misra, Wheeler, and Oliver, 1977).

MSR = Modified Simple Ratio (Chen, 1996).

$MSR_{RED\&RE}$ = Red and red-edge MSR index (Xie et al. 2018).

MSR_{RE} = Modified Simple Ratio Red-edge (Wu et al., 2008).

MSR_{REn} = Modified Simple Ratio red-edge normalized (Wu et al., 2008).

NBR = Normalized Burn Ratio (García and Caselles, 1991. Named by Key and Benson, 1999).

NBR-2 = Normalized Burn Ratio-2 (García and Caselles, 1991).

NDBaI = Normalized Difference Bareness Index (Zhao and Chen, 2005).

NDBI = Normalized Difference Built-up Index (Zha, Gao, and Ni, 2003).

NDFI = Normalized Difference Fraction Index (Souza Jr, Roberts and Cochrane, 2005).

NDII = Normalized Difference Infrared Index (Hardisky, Klemas and Smart, 1983).

NDMI = Normalized differences moisture index (Gerard et al., 2003).

NDTI = Normalized Difference Tillage Index (Van Deventer et al., 1997).

$NDVI_{RE}$ = Normalized Difference Vegetation Index Red-edge (Gitelson and Merzlyak, 1994).

$NDVI_{RE1n}$ = Normalized Difference Vegetation Index red-edge 1 narrow (Fernández-Manso, Fernández-Manso and Quintano, 2016).

$NDVI_{RE}2$ = Normalized Difference Vegetation Index red-edge 2 (Fernández-Manso, Fernández-Manso and Quintano, 2016).

$NDVI_{RE2n}$ = Normalized Difference Vegetation Index red-edge 2 narrow (Fernández-Manso, Fernández-Manso and Quintano, 2016).

NGRDI = Normalized Green Red Difference Index (Zarco-Tejada et al., 2001).

NRUI = Normalized Ratio Urban Index (Piyoosh and Gosh, 2018).

PPR = Plant Pigment Ratio (Metternicht, 2003).

PSRI = Plant Senescence Reflectance Index (Merzlyak et al., 1999).

PVR = Photosyntetic Vigour Ratio (Metternicht, 2003).

RedSWIR1 = Red and SWIR bands difference (Jacques et al., 2014).

REIP = Red-edge Inflection Point (Herrmann et al. 2011).

RERVI = Red-edge ratio vegetation index (Cao et al., 2013).

$RTVI_{core}$ = Red-edge Triangular Vegetation Index (Chen et al., 2010).

$SAVI_{R\&RE}$ = Soil-Adjusted Vegetation Index with red and red-edge (Vincent, Kumar, and Upadhyay, 2020).

SIPI = Structure Intensive Pigment Index (Peñuelas, Baret and Filella, 1995).

SIWSI = Shortwave Infrared Water Stress Index (Fensholt and Sandholt, 2003).

SRI (or SR) = Simple Ratio Index (Jordan, 1969).

$SR_{NIRnarrowGreen}$ = Simple ratio NIR narrow and Green (le Maire, François, and Dufrêne, 2004).

$SR_{NIRnarrowRed}$ = Simple ratio NIR narrow and Red (Blackburn, 1998).

STI = Soil Tillage Index (Van Deventer, 1997).

$SWIR_{Index}$ = Shortwave Infrared Index (Müller et al., 2015).

S2REP = Sentinel-2 Red-edge position (Frampton et al., 2013).

TVI = Transformed Vegetation Index (Broge and Leblanc, 2001).

$VARI_{GREEN}$ = Visible atmospherically resistant index green (Gitelson et al. 2001a).

VSDI = Visible and Shortwave Infrared Drought Index (Zhang et al., 2013).

Supplementary Table 3. Other less frequent vegetation indices that can be further explored as input for LULC mapping.

Spectral Vegetation Indices*	Equation for L8 bands	Equation for S2 bands
GRVI	b3 - b4/b3 + b4	(b3 - b4)/(b3 + b4)
LAnthoC	-	b7/b3 - b5
LCaroC		b7/b2 - b5
LChloC		b7/b5
MCARI	-	((b5 – b4) − 0.2*(b5 – b3))*(b5/b4)
MSI	-	b11/b8a
MTCI	-	(b6 - b5)/(b5 + b4)
NDRE1	-	(b6 – b5)/(b6 + b5)
NDRE2	-	(b7 – b5)/(b7 + b5)
$ND_{rededgeSWIR}$	-	(b6 - b12)/(b6 + b12)
NDre1m	-	(b6 – b5)/(b6 + b5 - 2* b1)
NDre2m	-	(b7 – b5)/(b7 + b5 - 2* b1)
NDSWIR	(b5 – b7)/(b5 + b7)	(b8 – b12)/(b8 + b12)
$NDVI_{RE}3$	-	(b8 - b7)/(b8 + b7)
$NDVI_{RE}3n$	-	(b8a - b7)/(b8a + b7)
NDVI705		(b6 - b5)/(b6 + b5)
NHI	(b6 – b3)/(b6 + b3)	(b11 – b3)/(b11 + b3)
NMDI	b5 − (b6 − b7)/b5 + (b6 − b7)	b8 - (b11 – b12)/b8 + (b11 – b12)
RBNDVI	(b5 - (b4 + b2))/(b5 + (b4 + b2))	(b8 - (b4 + b2))/(b8 + (b4 + b2))
REPA	-	b4 + b5 + b6 + b7 + b8a
$SRNIR_{narrowRE1}$		b8a/b5
$SRNIR_{narrowRE2}$		b8a/b6
$SRNIR_{narrowRE3}$		b8a/b7
SRre1	-	(b6 - b1)/(b6 - b1)
SRre2	-	(b7 - b1)/(b5 - b1)
TCARI	-	3[(b5 – b4) − 0.2(b5 – b3)(b5/4)]
VI_{700}	-	(b5 - b4)/(b5 + b4)
WBI	b2 - b4/b2 + b4	b2 - b4/b2 + b4
WDRVIre	-	(0.01*b7 – b5/0.01*b7 + b5) + (1 – 0.01/1 + 0.01)

***Description:**

GRVI = Green-Red Vegetation Index (Tucker, 1979).

LAnthoC = Leaf Anthocyanid Content (Wulf and Stuhler, 2015).

LCaroC = Leaf Carotenoid Content (Wulf and Stuhler, 2015).

LChloC = Leaf Chlorophyll Content (Wulf and Stuhler, 2015).

MCARI = Modified Chlorophyll Absorption in Reflectance Index (Daughtry et al. 2000).

MSI = Moisture Stress Index (Rock, Williams, and Vogelmann, 1985).

MTCI = MERIS Terrestrial Chlorophyll Index (Dash and Curran, 2004).

NDRE1 = Normalized Difference Red-edge (Gitelson and Merzlyak, 1994).

NDRE2 = Normalized Difference Red-edge (Barnes et al., 2000).

$ND_{Red\text{-}edgeSWIR}$ = Normalized Difference Red-edge and SWIR2 (Radoux et al., 2016).

$ND_{RE}1m$ = Normalized Difference Red-edge 1 modified (Sims and Gamon, 2002).

$ND_{RE}2m$ = Normalized Difference Red-edge 2 modified (Sims and Gamon, 2002).

NDSWIR = Normalized Difference SWIR (Gerard et al., 2003).

$NDVI_{RE}3$ = Normalized Difference Vegetation Index red-edge 3 (Gitelson and Merzlyak, 1994).

$NDVI_{RE}3n$ = Normalized Difference Vegetation Index red-edge 3 narrow (Fernández-Manso, Fernández-Manso, and Quintano, 2016).

NDVI705 = Red-edge Normalized Difference Vegetation Index (Gitelson and Merzlyak, 1994).

NHI = Normalized Humidity Index (Lacaux et al., 2007).

NMDI = Normalized Multi-band Drought Index (Wang and Qu, 2007).

RBNDVI = Red-Blue NDVI (Wang et al., 2007).

REPA = Red-edge Peak Area (Radoux et al. 2016).

$SR_{NIRnarrowRE}1$ = Simple NIR and Red-edge 1 Ratio (Datt, 1999b).

$SR_{NIRnarrowRE}2$ = Simple NIR and Red-edge 2 Ratio (Datt, 1999b).

$SR_{NIRnarrowRE}3$ = Simple NIR and Red-edge 3 Ratio (Datt, 1999b).

$SR_{RE}1$ = Surface Reflectance Red-edge 1 (Sims and Gamon, 2002).

$SR_{RE}2$ = Surface Reflectance Red-edge 2 (Sims and Gamon, 2002).

TCARI = Transformed Chlorophyll Absorption in Reflectance Index (Daughtry et al., 2000).

VI700 = Vegetation Index 700 (Gitelson et al., 2002).

WBI = Water Body Index (Domenech and Mallet, 2014).

$WDRVI_{RE}$ = Wide Dynamic Range Vegetation Index (Peng and Gitelson, 2011).

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