

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ



سپه پاسداری برای تولید

وزارت جهاد کشاورزی
سازمان تحقیقات، آموزش و ترویج کشاورزی
موسسه آموزش و ترویج کشاورزی



معاونت علمی و فناوری

شبکه دانش کشاورزی

سلسله برنامه‌های ویدیو کنفرانس انتقال دانش به روز در گستره ملی بخش کشاورزی

عنوان:

شاخص‌های سنجش از دوری و کاربردهای شان در کشاورزی و منابع طبیعی

سخنران:

علی اکبر دماوندی

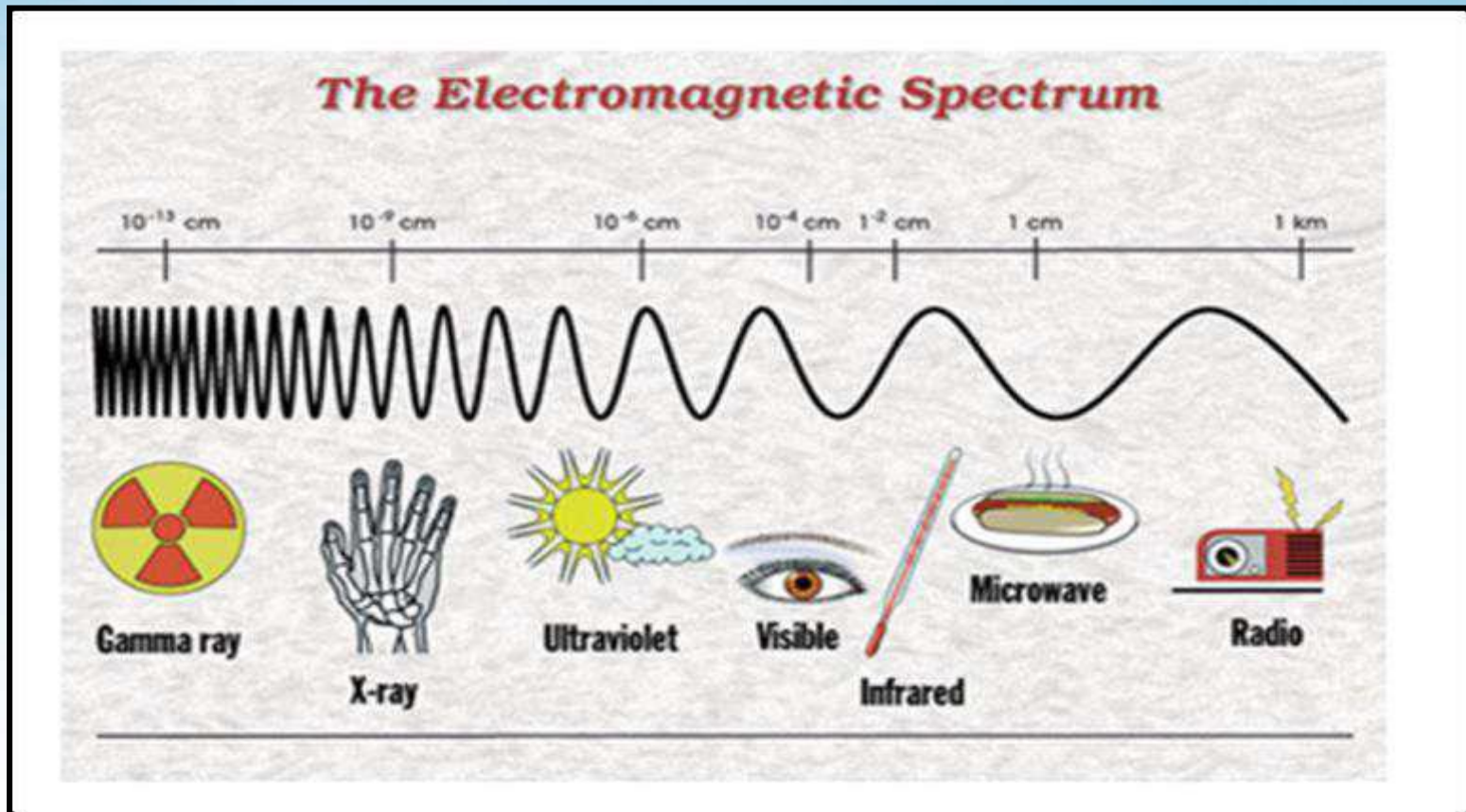
عضو

هیات علمی گروه منابع طبیعی و پژوهشگر مروج ارشد موسسه آموزش و ترویج کشاورزی

۶ آبان ۱۴۰۴ - ساعت: ۱۰

شاخص های سنجش از دوری و کاربرد های شان در کشاورزی و منابع طبیعی

Remote sensing indices and their applications in agriculture



تعریف سنجش از دور

سنجش از دور، فناوری و علمی است که به وسیله آن می توان مشخصه های یک شیء و یا پدیده را بدون تماس مستقیم، اندازه گیری یا تجزیه و تحلیل کرد (Lillesand, 1999).

سنجش از دور به معنای برداشت سطح زمین از فضا با استفاده از خصوصیات امواج الکترومغناطیس منعکس یا منتشر شده از سطح اشیا است. کاربرد سنجش از دور در مدیریت منابع طبیعی، تولید نقشه های کاربری و پوششی و حفظ طبیعت می باشد (UN, 1999).

سنجش از دور را می توان به عنوان ابزاری برای شناسایی و نقشه برداری پدیده ها بوسیله ابزارهای غیر مستقیم با استفاده از نیروهای طبیعی یا مصنوعی در نظر گرفت که در این بین مهمترین سیستم ها از انرژی های الکترومغناطیس برای شناسایی پدیده استفاده می کنند (Konecny, 2003).

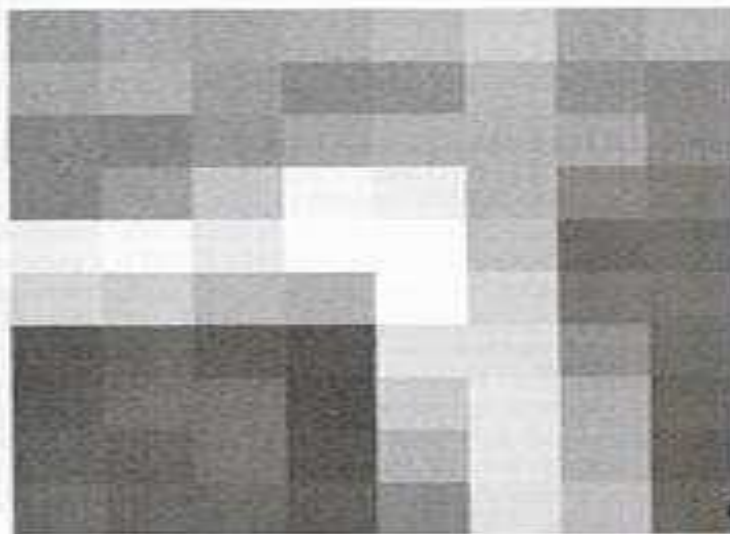
عبور از آنالوگ به رقومی شدن توسط ماهواره ها



a



b

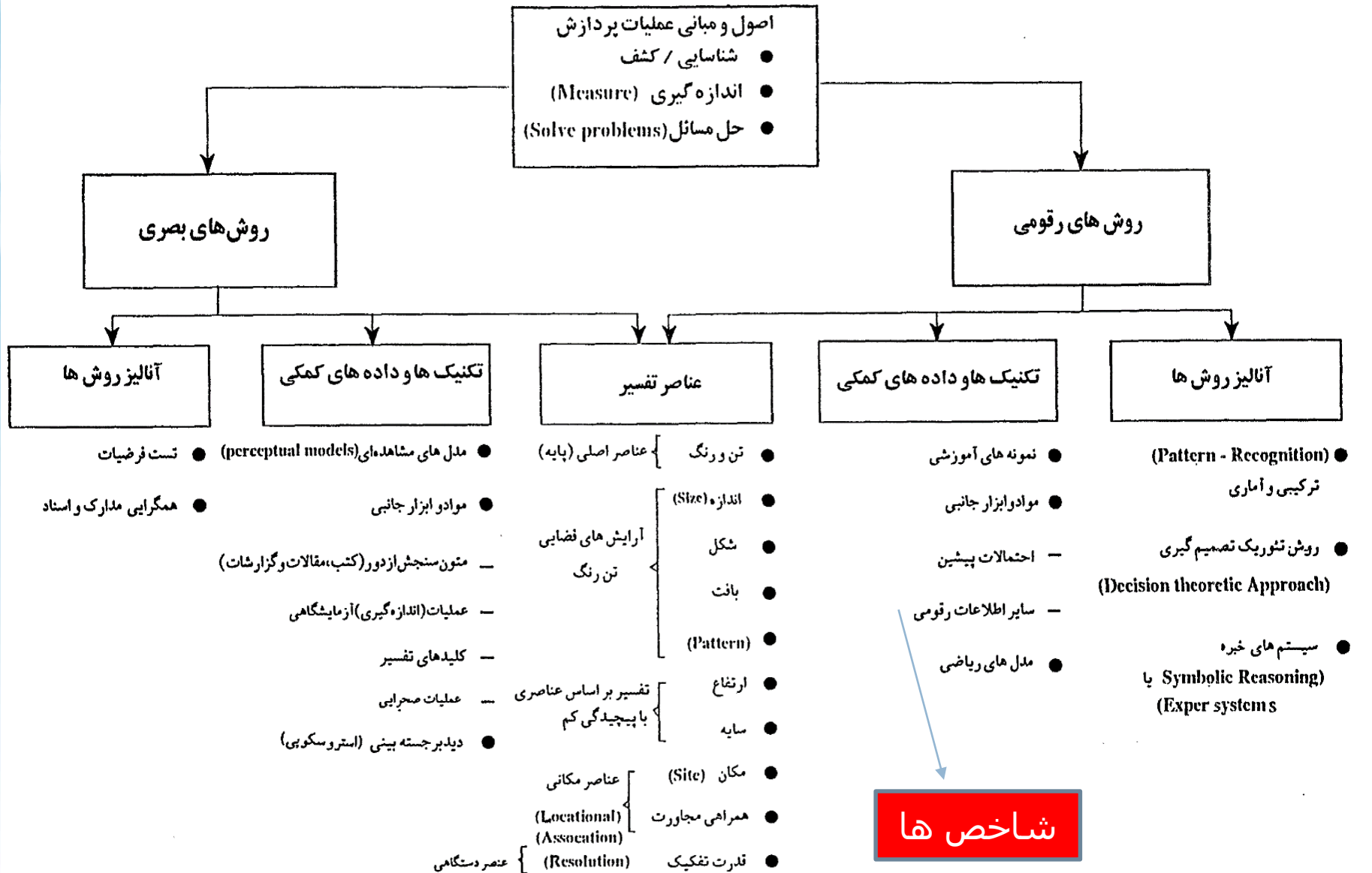


c

34	36	35	36	39	46	35	37
36	38	34	31	32	38	32	30
32	31	33	35	37	37	35	30
32	35	44	57	56	38	30	28
57	58	55	60	65	42	26	26
50	47	39	37	60	48	28	27
26	27	25	23	51	51	32	26
26	28	28	22	43	54	36	25
27	26	28	23	37	54	37	24
28	26	26	24	31	53	40	25

d

روش های تفسیر تصاویر و عکس ها





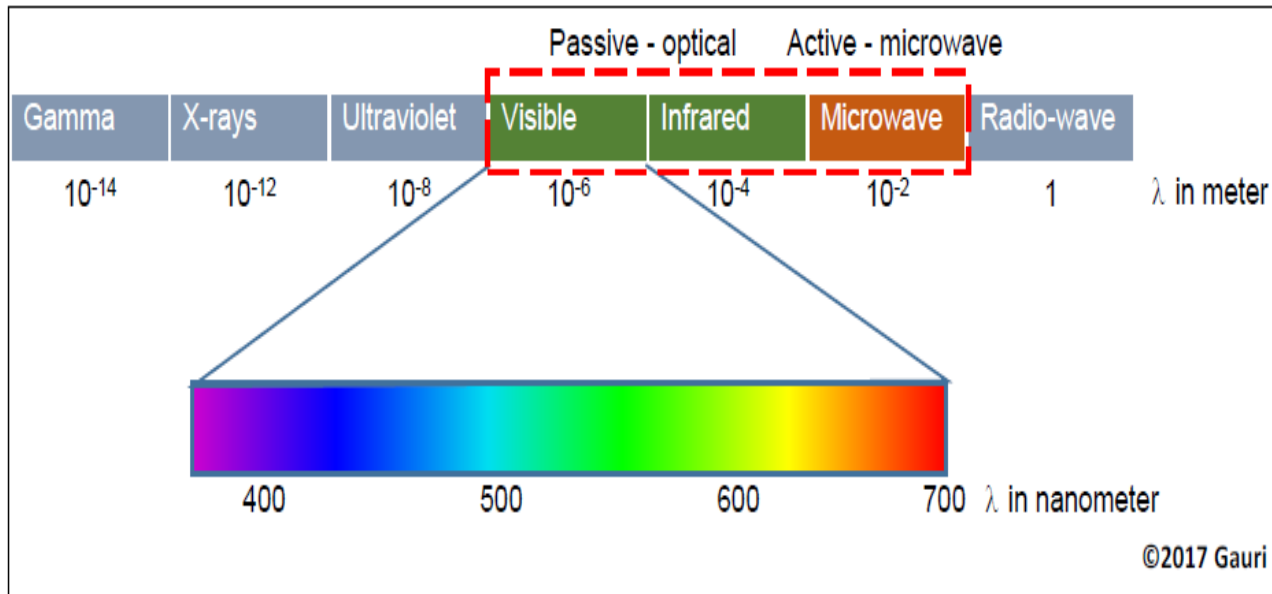
4 Resolutions of Remote Sensing

- Spatial:
 - X and Y resolution
- Spectral:
 - Number of bands
- Temporal:
 - Number of samples per time unit
- Radiometric:
 - Number of bits or bytes per sample

شاخص های سنجش از دوری

Electromagnetic spectrum (EMR)

From very short Gamma rays to very long radio waves



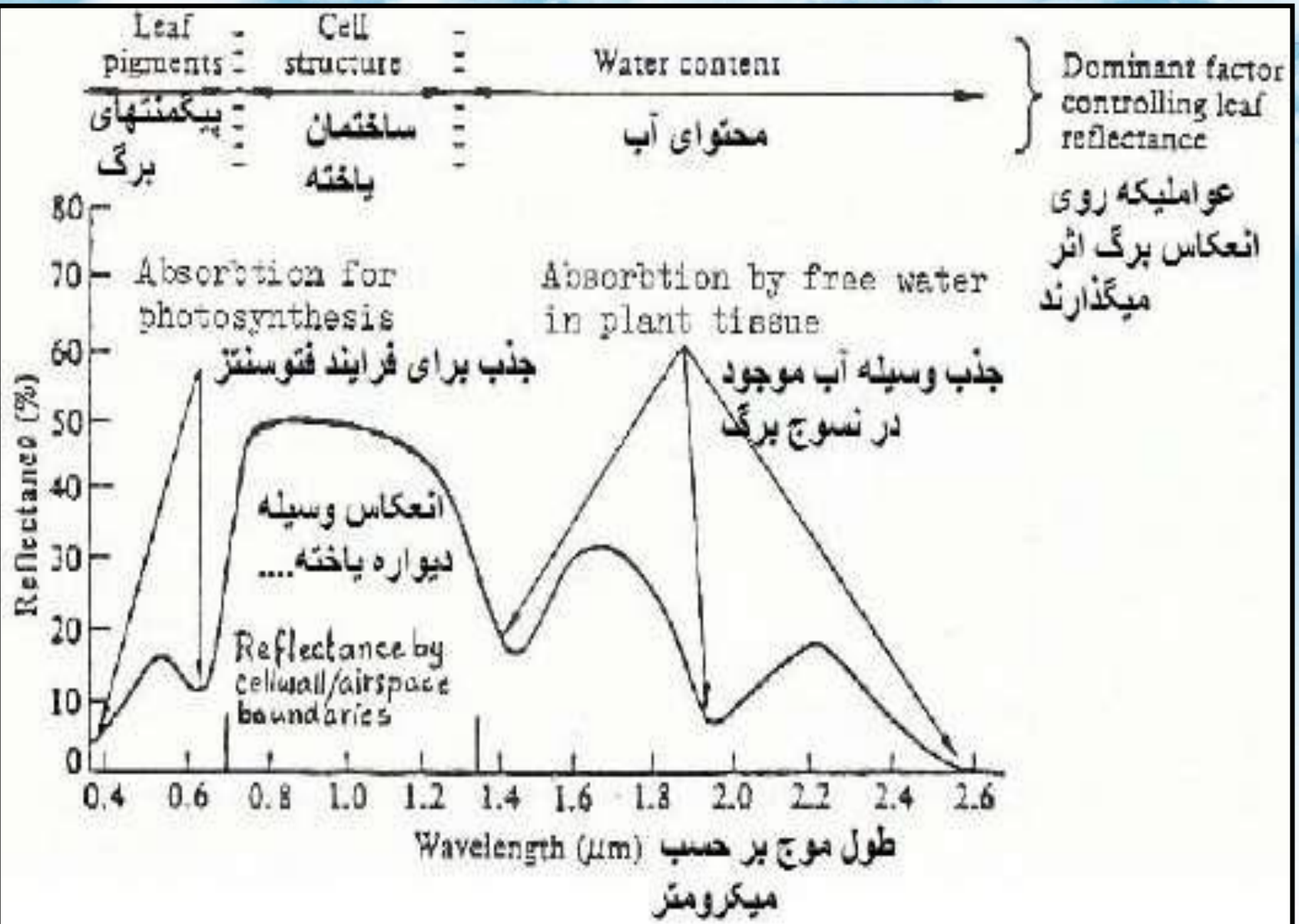
Blue (400 – 500), Green (500 – 600) and Red (600 – 700nm) bands

اساس تشخیص پدیده ها در
سنجش از دور:

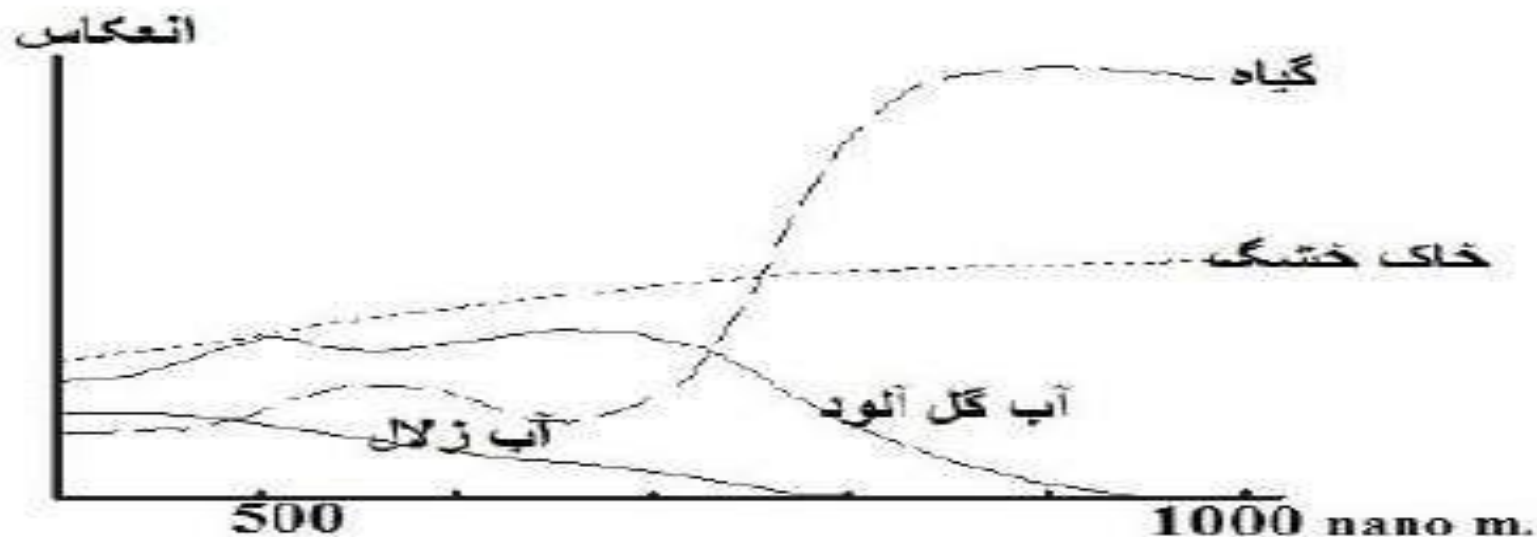
۱- تفاوت رفتار طیفی یک
پدیده در طول موج های
مختلف

۲- تفاوت رفتار طیفی پدیده
های مختلف در یک ناحیه
طیفی

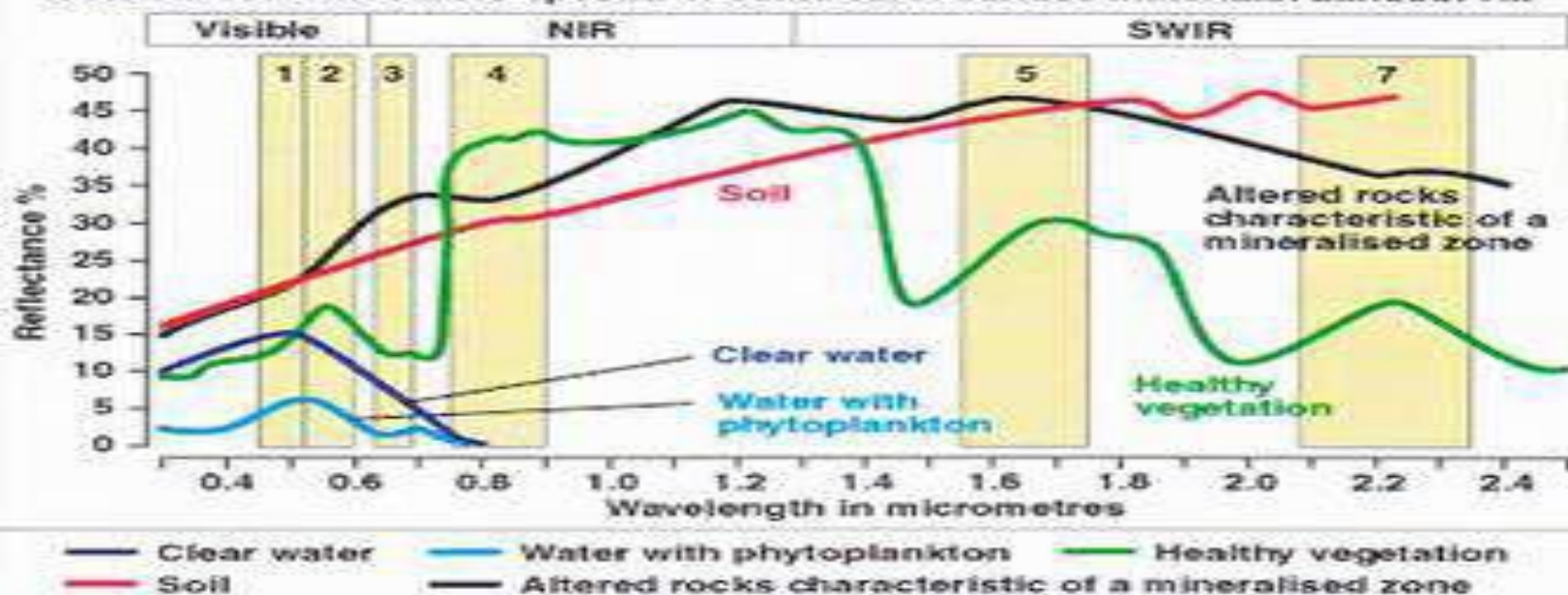
انعکاس طیفی گیاهان سبز



انعکاس طیفی پدیده های طبیعی

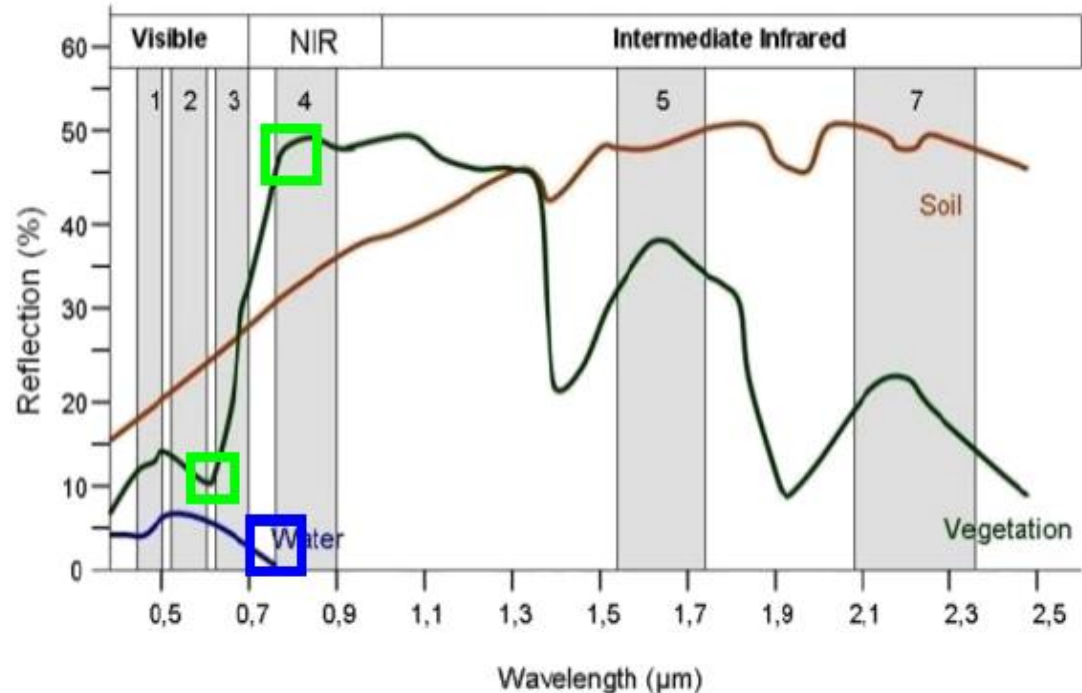


Generalised reflectance spectra of some earth surface materials: Landsat TM



Why band ratio?

- Specific target has an individual and characteristic manner of interacting with incident radiation
- Interaction are described by the **spectral response** of the target in a particular wavelength of EMR



Spectral curves for various natural features

Differences between histogram

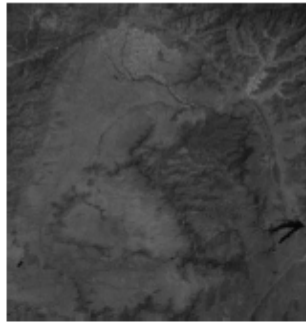
Histogram of Red and near-infrared reflectance representing more pixel frequency at higher reflectance in NIR of Sentinel-2A data



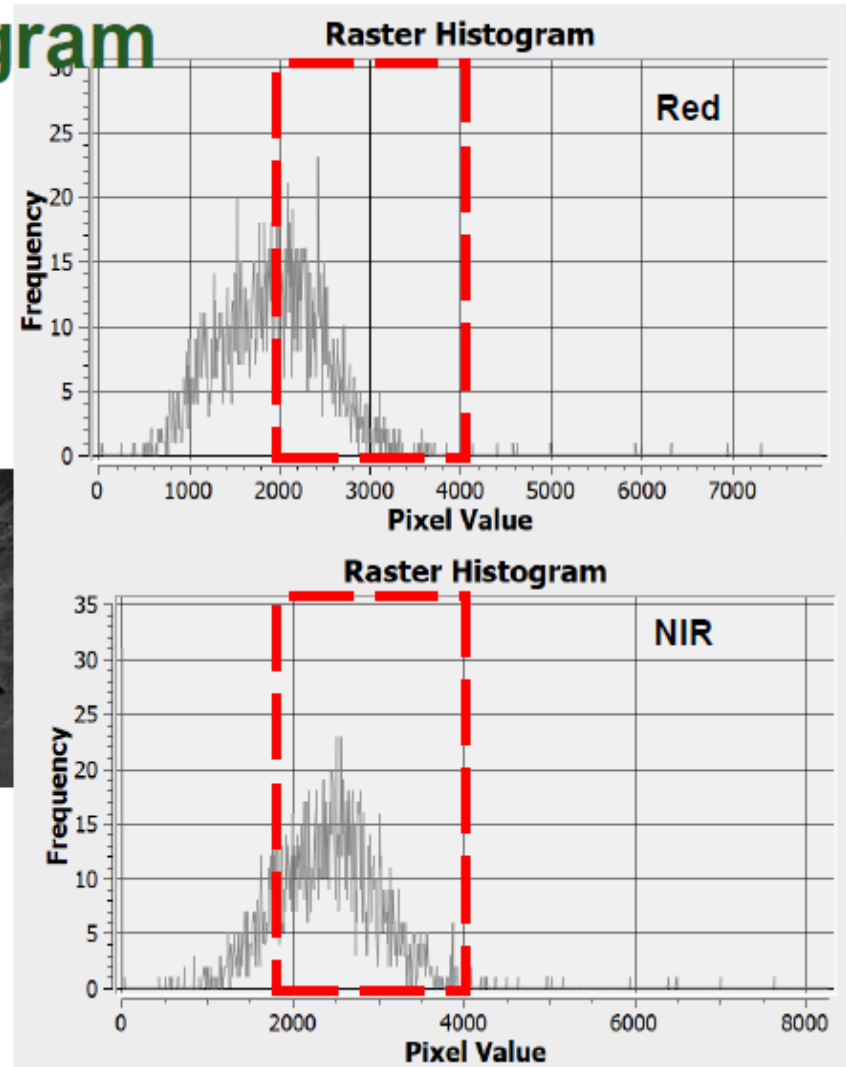
GEE



B4 (Red)



B6 (NIR)



Spectral indices

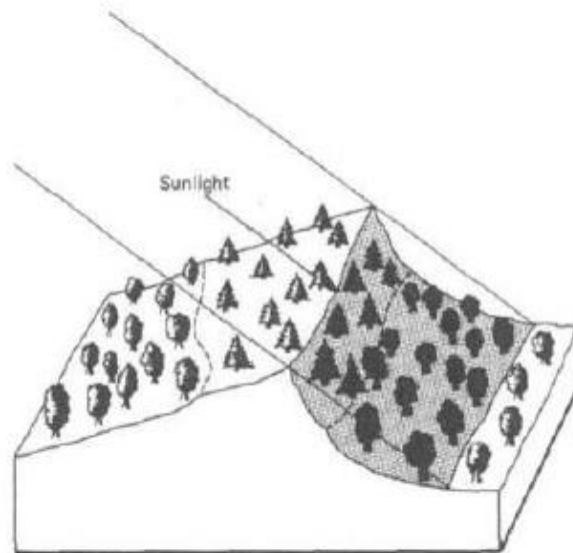
1. Spectral indices help in **modelling, predicting, or infer surface processes**
2. Developed to assess and monitor several **land change processes**
3. Computed from multiband images by **adding and subtracting bands** thereby making various **band ratio**
4. **Emphasizes** a specific phenomenon that is present, while **mitigating** other factors
 - Vegetation health and status
 - Burned area
 - Fire severity etc.

Development of spectral indices

1. Initially **intrinsic indices** were developed from simple band ratios, which highlighted the spectral properties of **vegetation** at different stages of growth and senescence.
2. To compensate for **background effects** such as that caused in areas in which the **soil response** dominates over the vegetation.
3. To compensate for the effects of **atmospheric distortion**.
4. Development of **new spectral indices** to applications other than vegetation health. These include indices for burned area assessment and fire severity etc.

Use of ratio to reduce topographic effects

Example 1



Land Cover/ Illumination	Digital Number		
	Band A	Band B	Ratio (Band A/Band B)
Deciduous			
Sunlit	48	50	0.96
Shadow	18	19	0.95
Coniferous			
Sunlit	31	45	0.69
Shadow	11	16	0.69

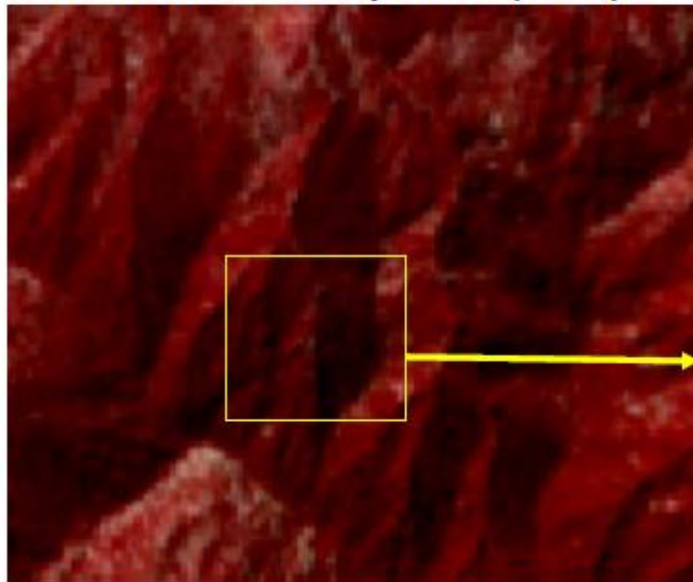
Figure 7.25 Reduction of scene illumination effects through spectral ratioing. (Adapted from Sabins, 1997.)

NB. The objective is to map 2 classes –coniferous and deciduous forest

Use of indices to reduce topographic effects

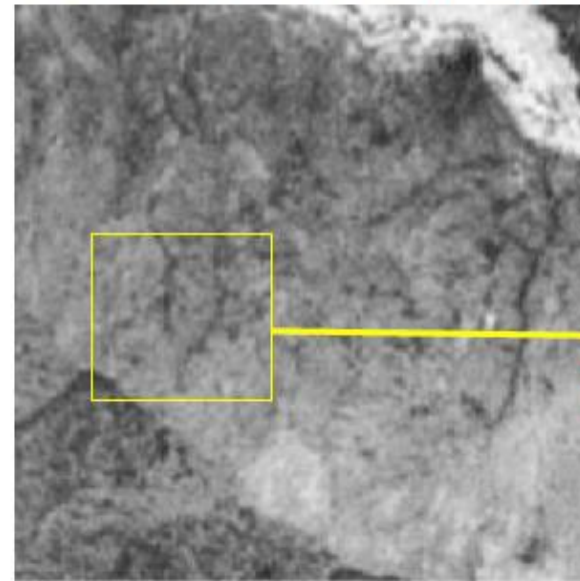
Example 2 from Kabul

False color composite (FCC)



R: 703
NIR: 1502
R:480
NIR:1018

Normalized difference
vegetation indices (NDVI)



Sunlit: 0.36
Shaded:0.359

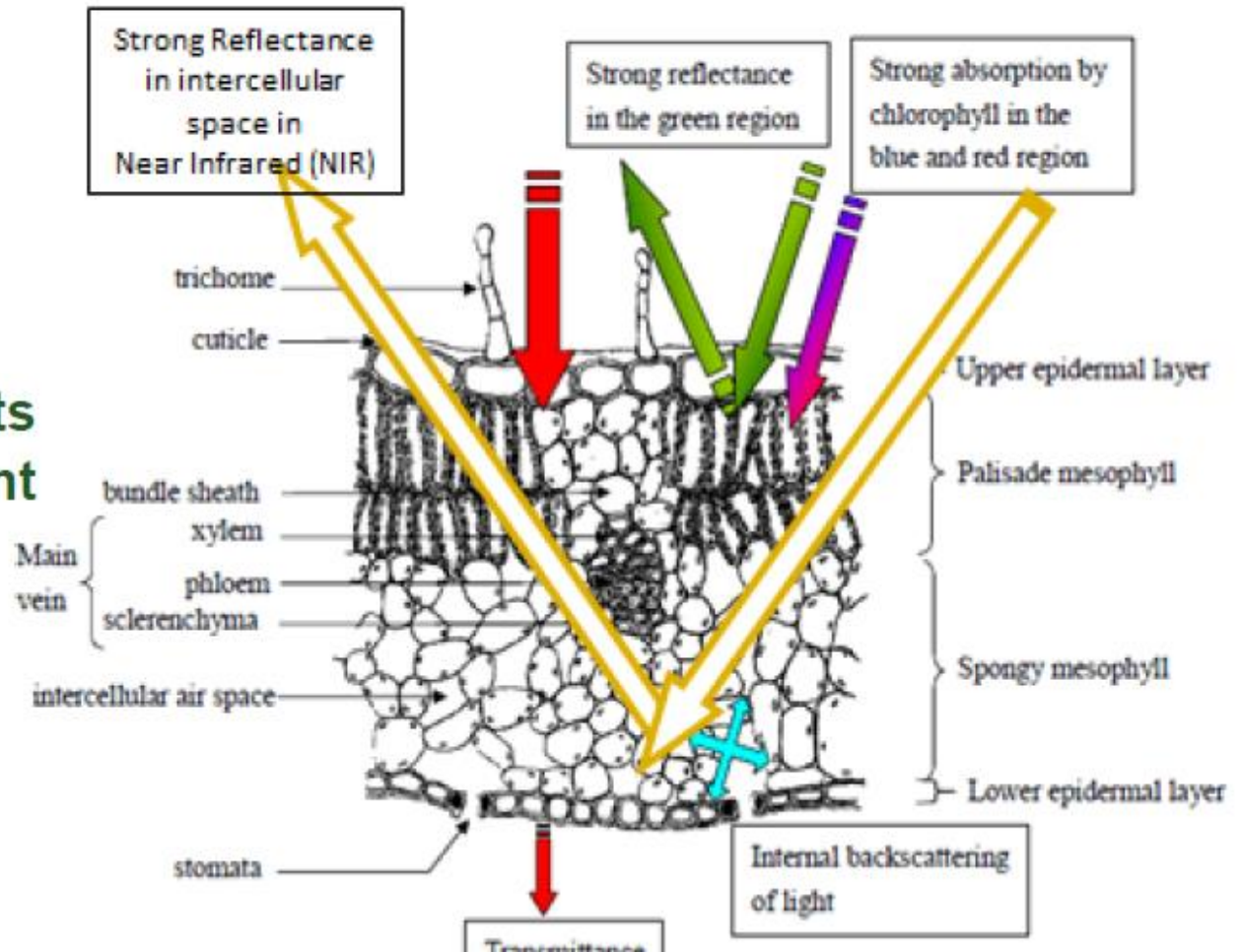
R and NIR represents the reflectance in red and near infra-red band of Sentinel for **SUNLIT** and **SHADED region** and their respective ratio in NDVI image

Vegetation indices

- **Enhances** green vegetation so that plants appear distinct from other image features
- Reflectance of light spectra from plants changes with **plant type, water content within tissues**, and other intrinsic factors
- Vegetation reflectance is determined by **chemical and morphological** characteristics of the surface of organs or leaves e.g. leaf structure, leaf pigments etc.

Vegetation indices

Leaf structure and its responses in different EMR region



Vegetation indices

❖ Simple Difference Vegetation Index

$$\text{DVI} = \text{NIR} - \text{R} \quad (\text{Richardson et al., 1977})$$

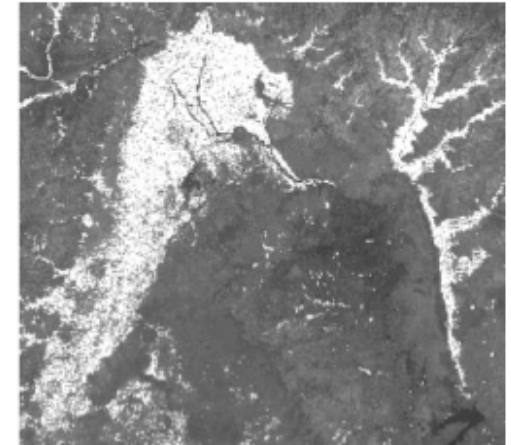
- Distinguishes between **soil** and **vegetation**
- Does Not deal with the **atmospheric effects**

❖ Ratio-based Vegetation Index

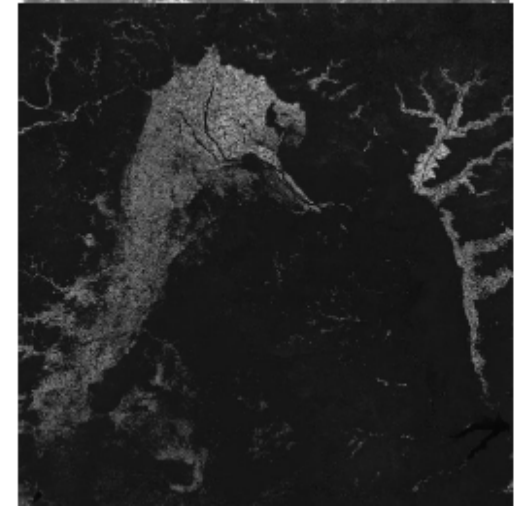
$$\text{RVI} = \text{R}/\text{NIR} \quad (\text{Jordan 1969})$$

- Reduces the effects of **atmosphere** and **topography**
- **Low** for soil, ice, water, etc.

DVI



RVI



Vegetation indices

❖ Normalized Difference Vegetation Index

- Standard method for comparing the vegetation greenness from satellite
- $NDVI = (NIR) - (RED) / (NIR) + (RED)$
- Explains density of vegetation
- The NDVI values tentatively ranges between **-1 to +1**, the values close to +1 denotes the **good health** of vegetation

HEALTHY
VEGETATION REFLECTANCE

50% NIR 8% RED



NDVI = 0.72

STRESSED
VEGETATION REFLECTANCE

40% NIR 30% RED



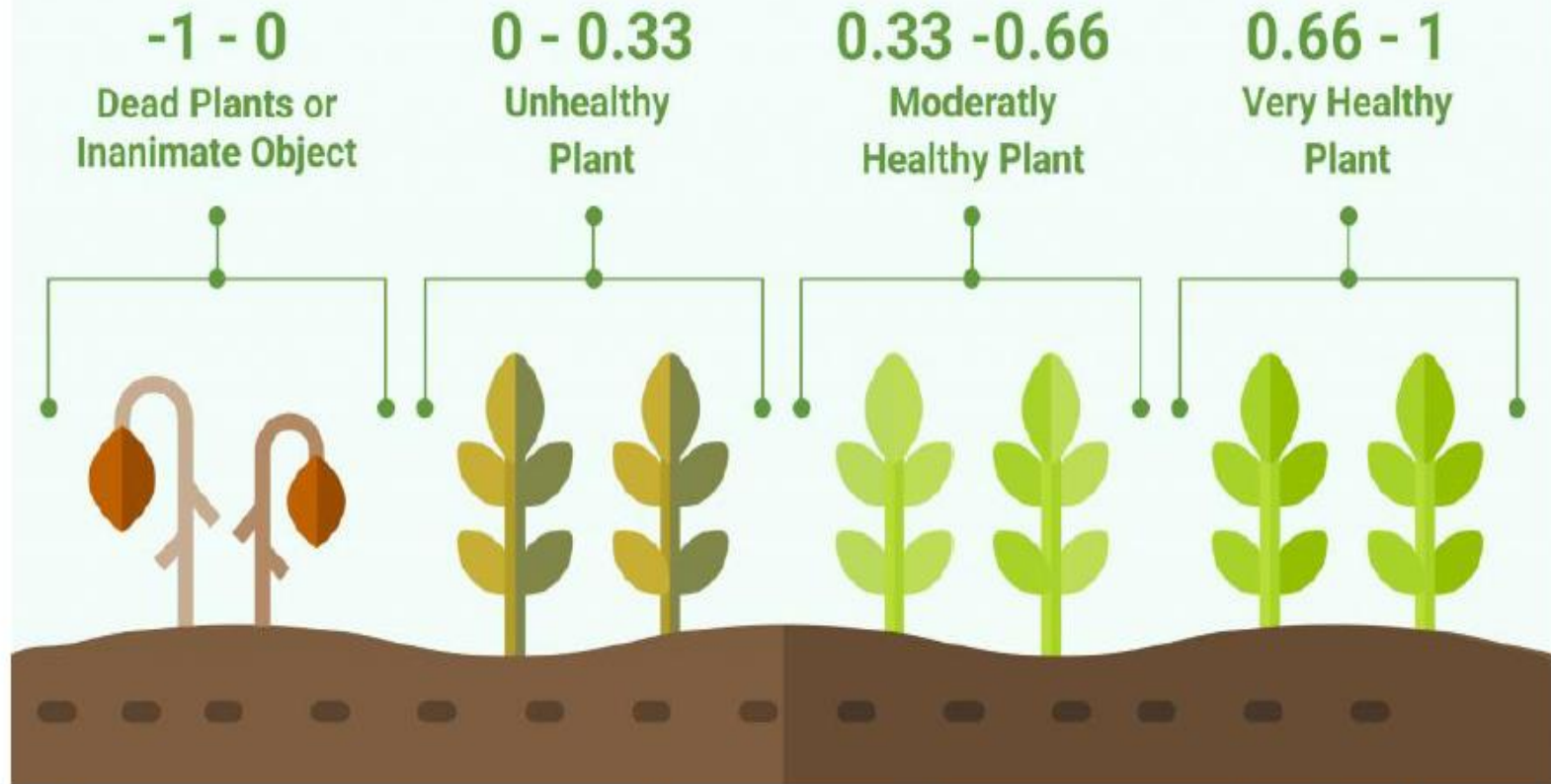
NDVI = 0.14

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

NDVI is sensitive to the effects of soil and atmosphere and saturates at high density of vegetation

Vegetation indices

NDVI



- **Negative values** correspond to areas with **water surfaces, manmade structures, rocks, clouds, snow**;
- Plants will always have positive values between **0.2 and 1**.

Vegetation indices

❖ Soil Adjusted Vegetation Index

- The concept of distinction of vegetation from the **soil background** was proposed by *Richardson and Wiegand., 1977*
- Soil background conditions exert considerable influence on partial canopy spectra and the calculated vegetation indices

$$\text{SAVI} = ((\text{NIR} - \text{Red}) / (\text{NIR} + \text{Red} + L)) \times (1 + L) \text{ Huete, 1988}$$

- Minimizes soil brightness influence
- L is a variable ranges within **-1 to 1**, depending on the amount of green vegetation present in the area
- To run the remote sensing analysis of areas with high green vegetation, L is set to be zero (in which case SAVI index data will be equal to NDVI); whereas low green vegetation regions require L=1

Vegetation indices

❖ **Atmospherically Resistant Vegetation Index (ARVI; Kaufman and Tanré, 1992)**

- Relatively prone to atmospheric factors (such as aerosol)
- Atmosphere affects significantly **Red** region compared to the **NIR**
- Corrected for atmospheric scattering effects in the red reflectance spectrum by using the measurements in blue wavelengths.

$$\text{ARVI} = (\text{NIR} - (2 * \text{Red}) + \text{Blue}) / (\text{NIR} + (2 * \text{Red}) + \text{Blue})$$

- Eliminates the effect of atmospheric aerosols
- Monitoring tool for tropical mountainous regions often polluted by soot coming from slash-and-burn agriculture

Vegetation indices

❖ Land Surface Water Index (LSWI)

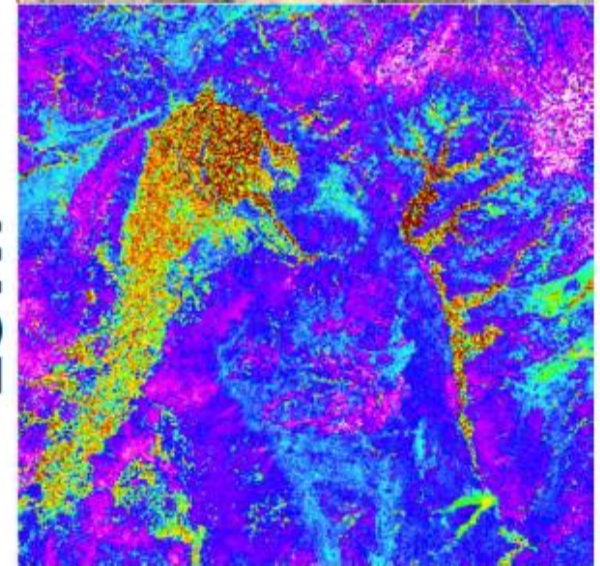
NIR-SWIR/NIR+SWIR

LSWI is sensitive to changes in vegetation canopy water content and indicates the water stress

❖ Vegetation Condition Index (VCI)

$$(\text{NDVI} - \text{NDVI}_{\min} / \text{NDVI}_{\max} - \text{NDVI}_{\min}) * 100$$

Lower and higher values indicate bad and good vegetation state conditions



LSWI

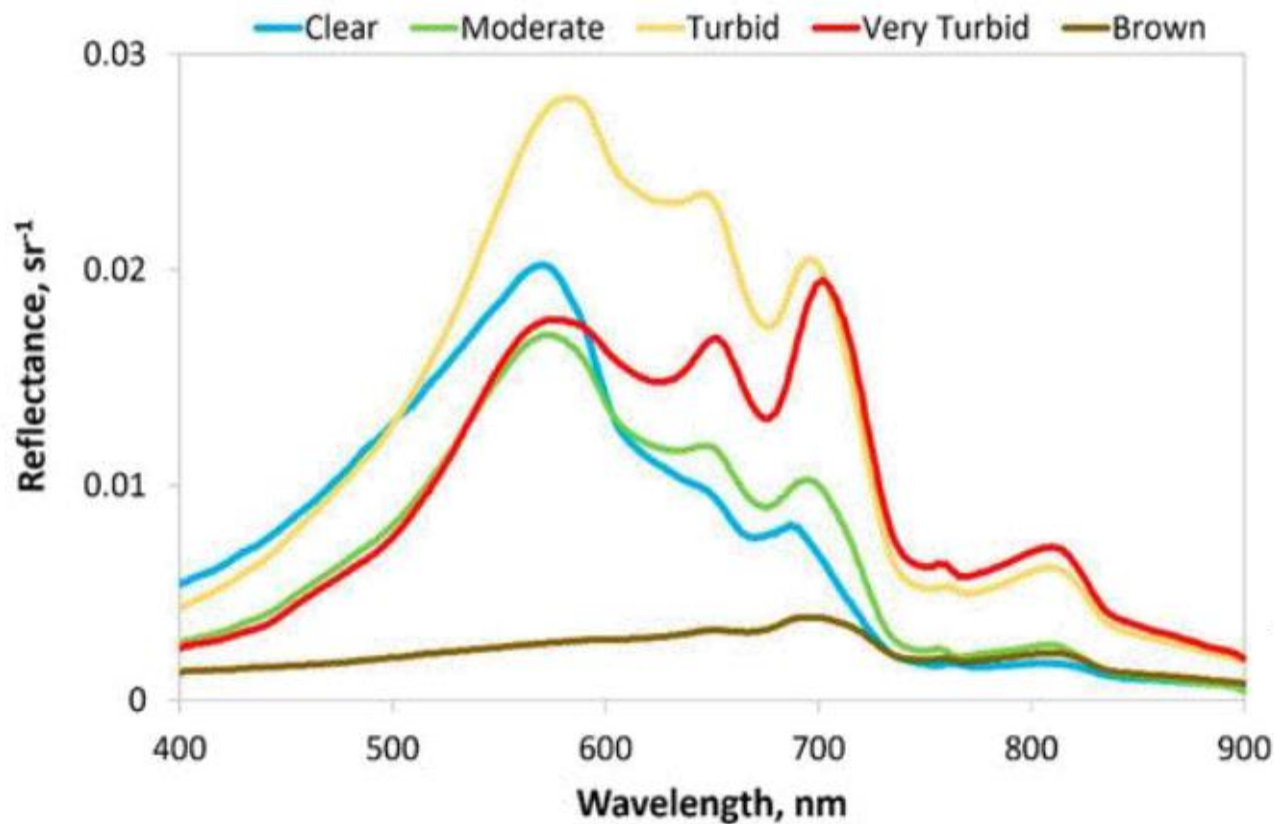
Water indices

- Used to highlight the water bodies while suppressing the other land cover
- Water **absorbs more energy** (low reflectance) **in NIR and SWIR** wavelengths
- Have the **greatest reflectance** in the **blue portion** of the visible spectrum
- Clear water has **high absorption** and virtually no reflectance in near infrared wavelengths range and beyond

Factors affecting water

- **Algae:** Water with higher algal density reflect more in **green** bands
- **Turbidity:** Turbid water has a **higher reflectance** in the visible region than clear water. This is also true for waters containing high chlorophyll concentrations

Water indices



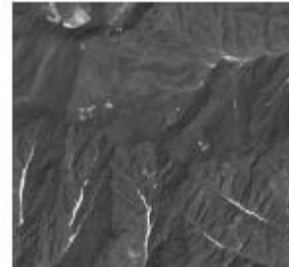
Adapted from *Kristi Udeberg, 2019*

Reflectance response of water with different levels of turbidity

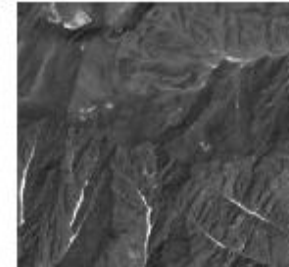
Snow indices

- Ice and snow generally have **high reflectance** across **all** visible wavelengths, thus bright white appearance
- The **low reflection** of ice and snow in the **SWIR** is related to their **microscopic liquid water content**

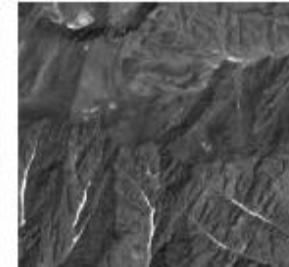
Blue



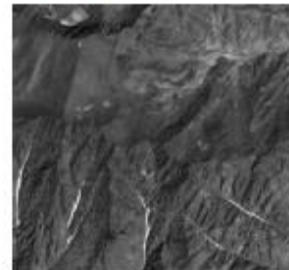
Green



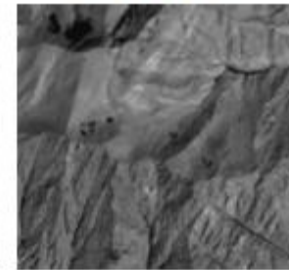
Red



NIR



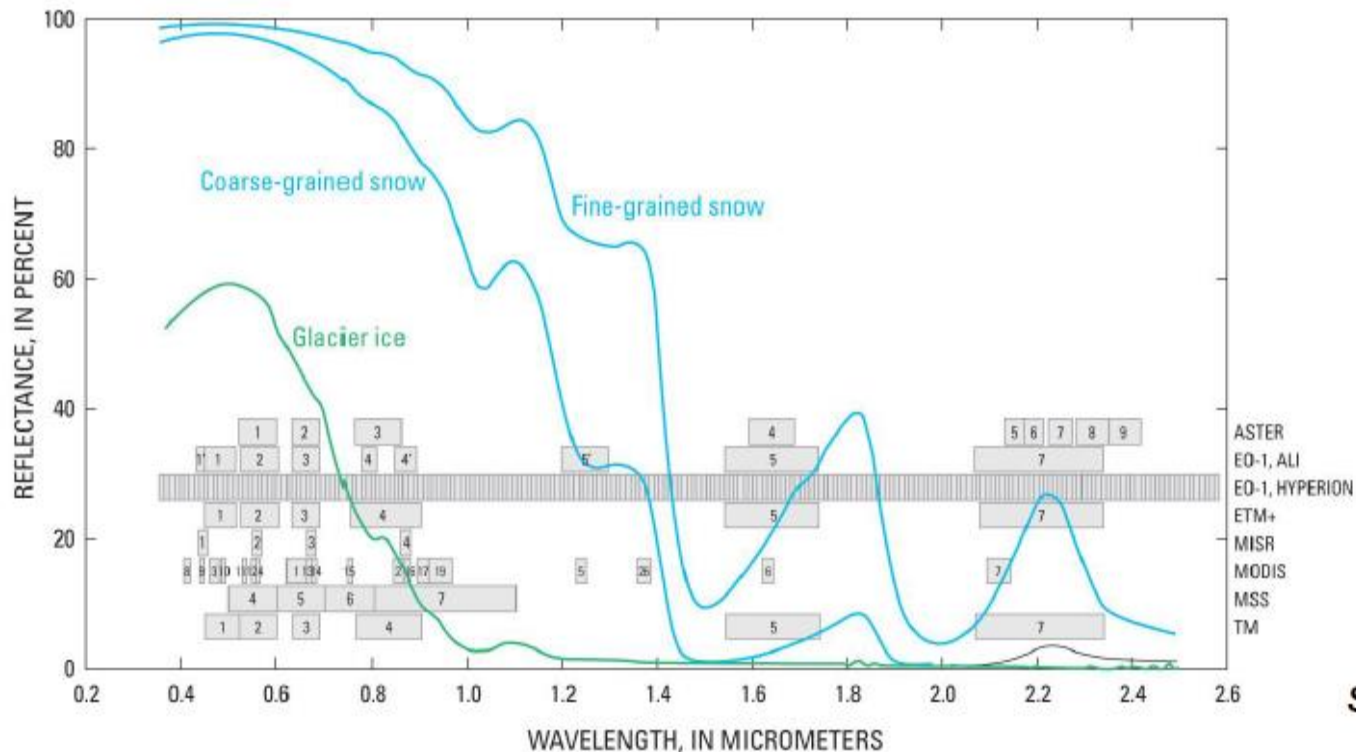
SWIR



FCC



Snow indices



Source: USGS

Spectral reflectance curves of bare glacier ice, coarse-grained snow, and fine-grained snow. Spectral bands of selected sensor on Earth-orbiting satellites are shown in gray. The numbers in the gray boxes refer to the associated band numbers of each sensor

Water and snow indices

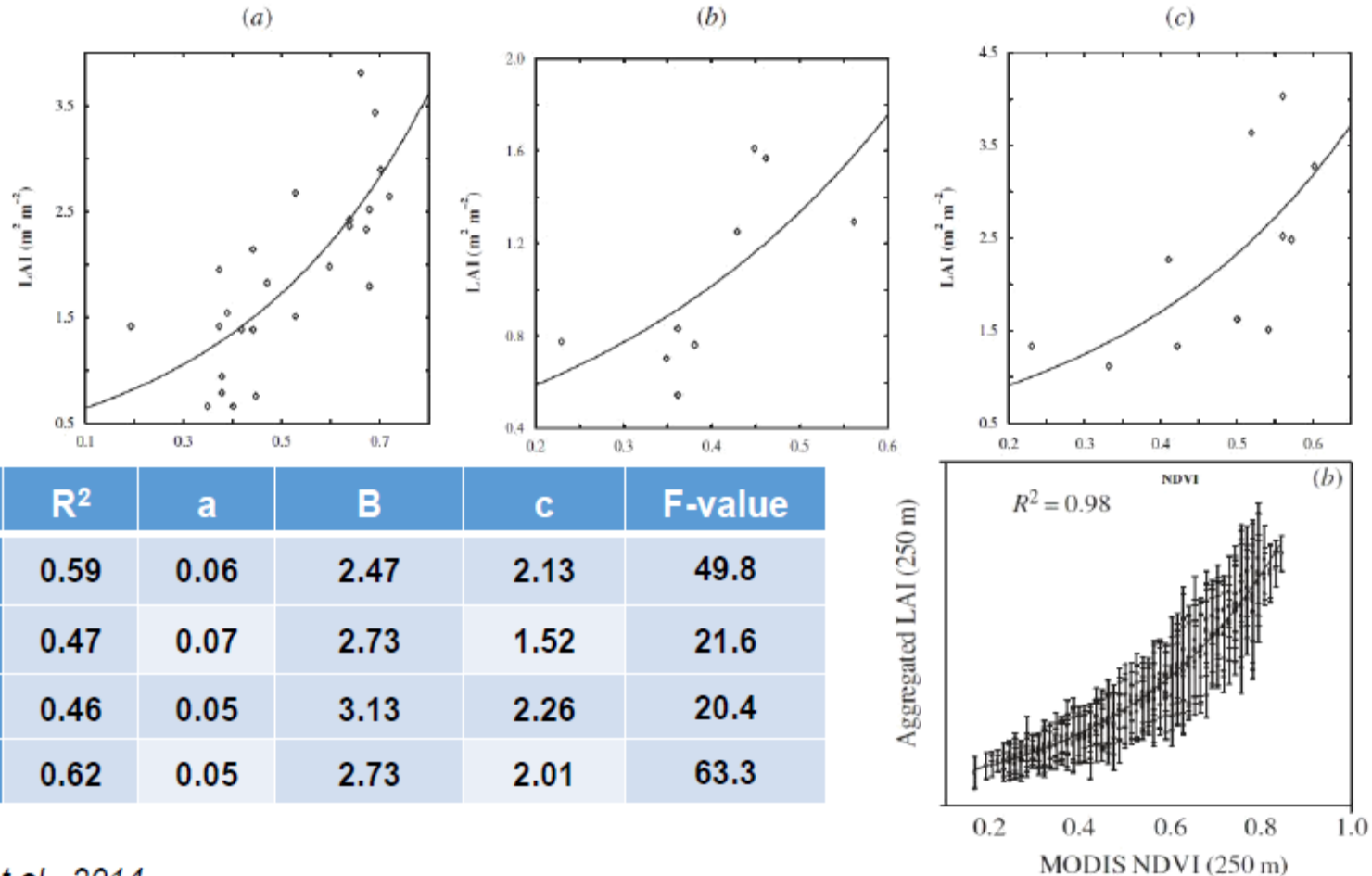
Indices	Formula
Normalized Difference Water Index (NDWI)	$\text{GREEN-NIR}/\text{GREEN+NIR}$
Modified Normalized Difference Water Index (MNDWI)	$\text{GREEN-SWIR}/\text{GREEN+SWIR}$
Normalized Difference Pond Index (NDPI)	$\text{MIR-GREEN}/\text{MIR+GREEN}$
Water Ration Index (WRI)	$\text{GREEN+RED}/\text{NIR+SWIR}$
Normalized Difference Turbidity Index (NDTI)	$\text{RED-GREEN}/\text{RED+GREEN}$
Automated Water Extraction Index (AWEI)	$4*(\text{GREEN-SWIR}^2 - 0.25*\text{NIR} + 2.75*\text{SWIR})$
Normalized Difference Snow Index (NDSI)	$\text{GREEN-SWIR}/\text{GREEN+SWIR}$
Normalized Difference Snow and Ice Index (NDSII-1)	$\text{RED-SWIR}/\text{RED+SWIR}$
Snow Water Index (SWI)	$\text{GREEN} * (\text{NIR-SWIR}) / (\text{GREEN+NIR})(\text{NIR+SWIR})$

Application of vegetation indices

- Vegetation mapping and monitoring
 - Biodiversity assessment
 - Estimation of biophysical parameters (LAI, $fPAR$)
 - Phenological assessment
 - Vegetation health/stress
 - Forest degradation
 - Biomass mapping and modelling
 - Productivity and carbon assessment
 - Crop condition monitoring and predicting crop yield
-

Application of vegetation indices

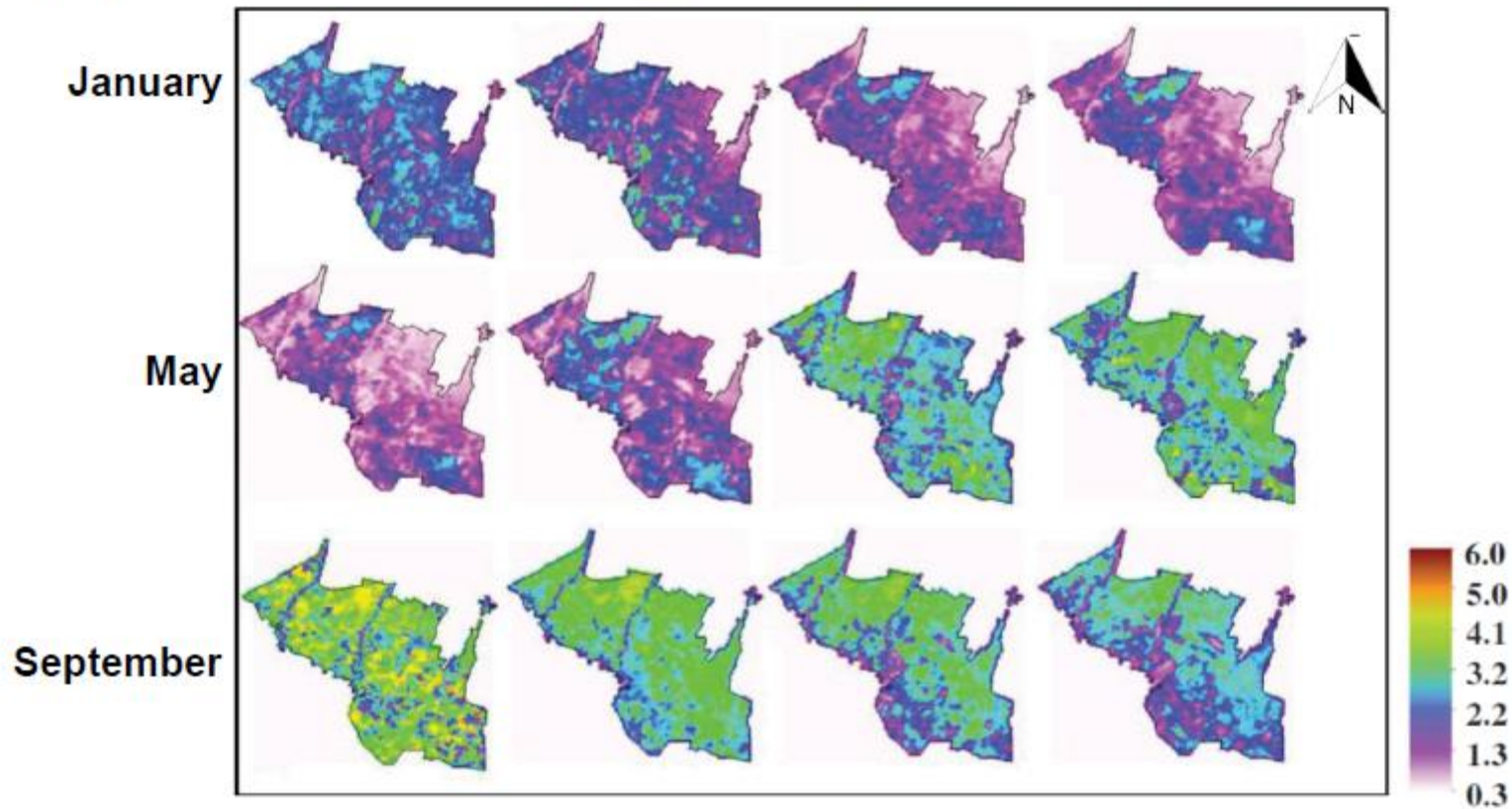
Leaf area index (LAI) estimation



Plantation	R ²	a	B	c	F-value
a) Mixed	0.59	0.06	2.47	2.13	49.8
b) Eucalyptus	0.47	0.07	2.73	1.52	21.6
c) Poplar	0.46	0.05	3.13	2.26	20.4
d) All plantation	0.62	0.05	2.73	2.01	63.3

Source: Tripathi et al., 2014

Application of vegetation indices



Monthly pattern (January- December) of leaf area index (LAI) derived from NDVI (exponential relationship)

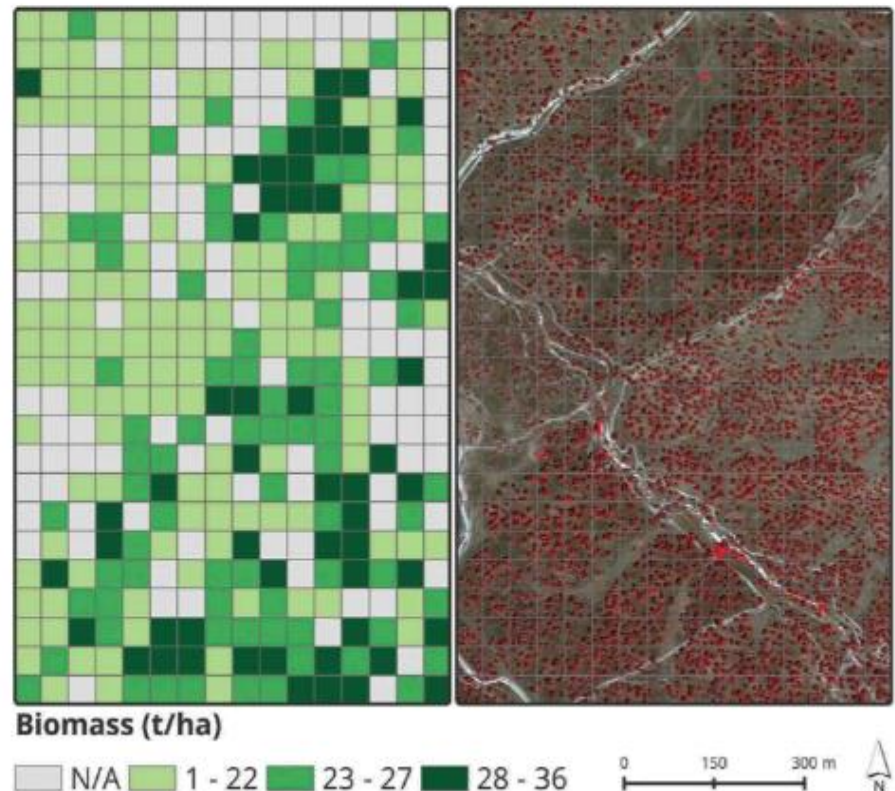
Application of vegetation indices

Biomass estimation

	AGB (t/ha)	CC (%)
AGB (t/ha)	1	
CC (%)	0.83	1
NDVI	0.85	0.95
EVI	0.75	0.91
SR	0.86	0.96
SAVI	0.70	0.84

Correlation between above ground biomass and vegetation indices for *Quercus rotundifolia*

Source: Macedo et al., 2018, southern Portugal



Application of vegetation indices

Drought Assessment

TABLE 1.
Remote sensing data, indices and thresholds relevant to drought assessment used in the study.

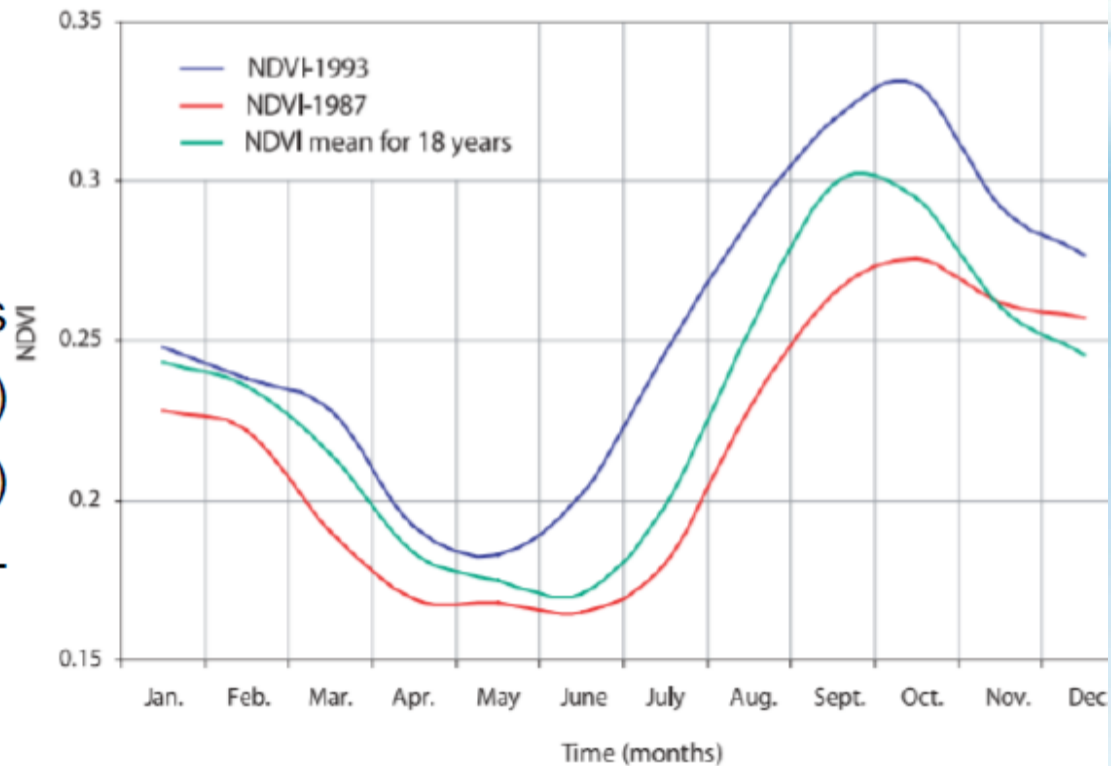
Drought index	Band or index used to compute the index		Range	Normal condition	Severe drought	Healthy vegetation
	AVHRR	MODIS				
1. Normalized difference vegetation index (NDVI)	Band 1 (0.58-0.68 μ m)	Band 1 (0.62-0.67 μ m)	-1 to +1	Depends on the location	-1	+1
	Band 2 (0.73-1.10 μ m)	Band 2 (0.84-0.87 μ m)				
2. Drought severity index (DEV_{NDVI})	NDVI NDVI long-term mean	NDVI NDVI long-term mean	-1 to +1	0	-1	+1
3. Vegetation condition index (VCI)	NDVI NDVI long-term minimum NDVI long-term maximum	NDVI NDVI long-term minimum NDVI long-term maximum	0 to 100 %	50 %	0%	100%

Source: Thenkabail and Gamage, 2004

Application of vegetation indices

Southwest Asia NDVI deviation

- A monthly NDVI time series for a drought year (1987) and a wet year (1993) compared to the NDVI long-term mean



Source: Thenkabail and Gamage, 2004

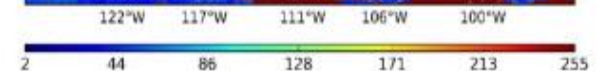
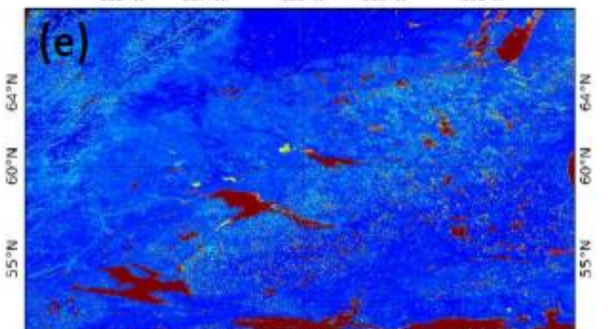
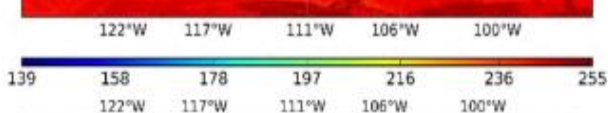
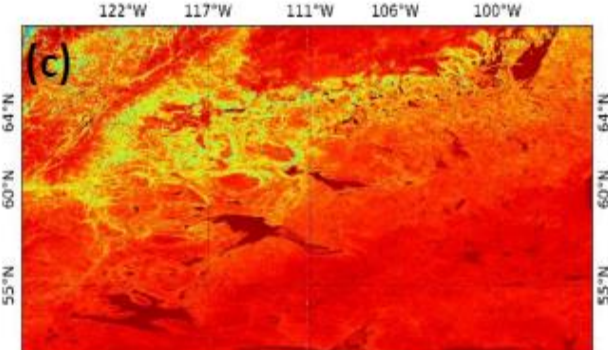
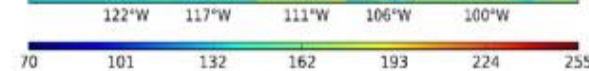
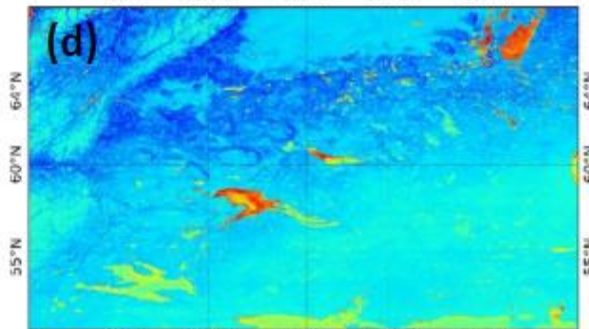
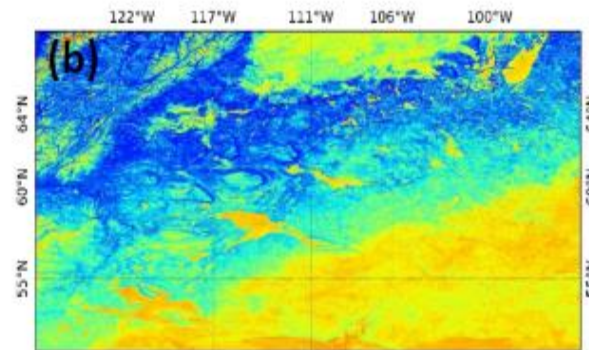
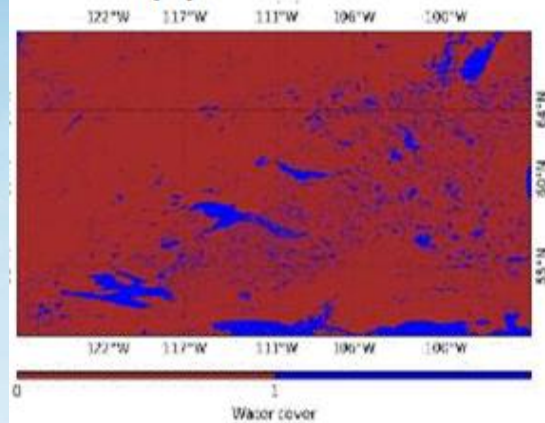
Application of water and snow indices

- Water mapping and monitoring
- Change detection
- Water quality assessment
- Flood monitoring and damage assessment
- Algae assessment
- Snow and ice mapping and monitoring

Application of water indices

Water mapping

(a)



Source: Sharma et al, 2015

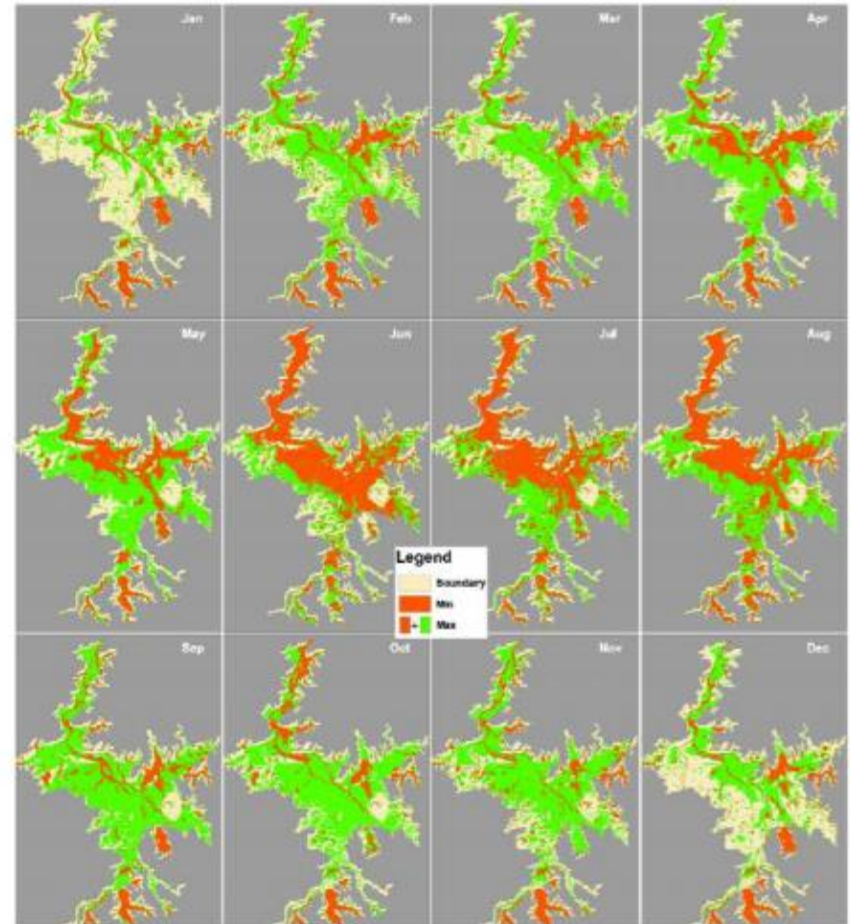
(a) Reference water cover map (b) Automated water extraction index (AWEI), (c) Modified normalized difference water index (MNDWI) (d) Normalized difference water index (NDWI), (e) Superfine water index (SWI)

Application of water indices

Water inundation mapping

- Minimum and maximum inundation areas and their distributions during each climatological month between 2000 and 2010 for Poyang Lake, China

Source: Feng et al. (2012)



Application of water indices

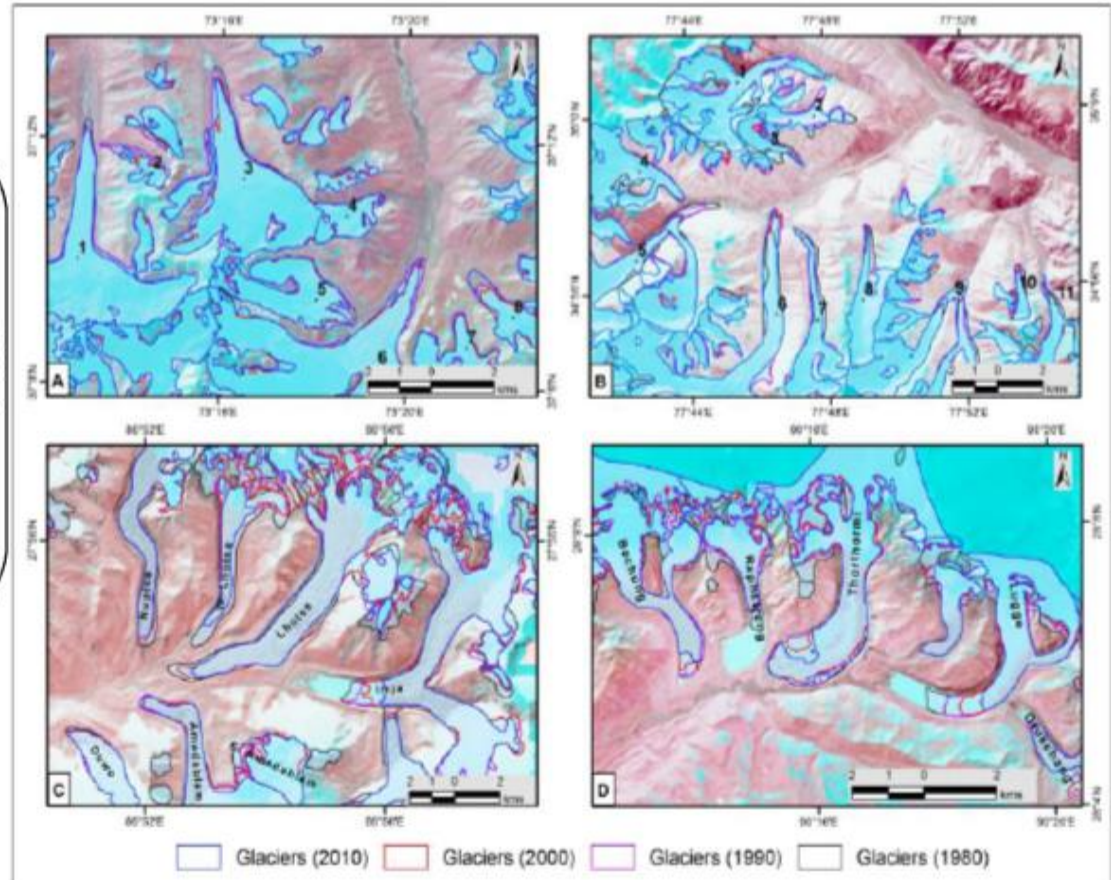
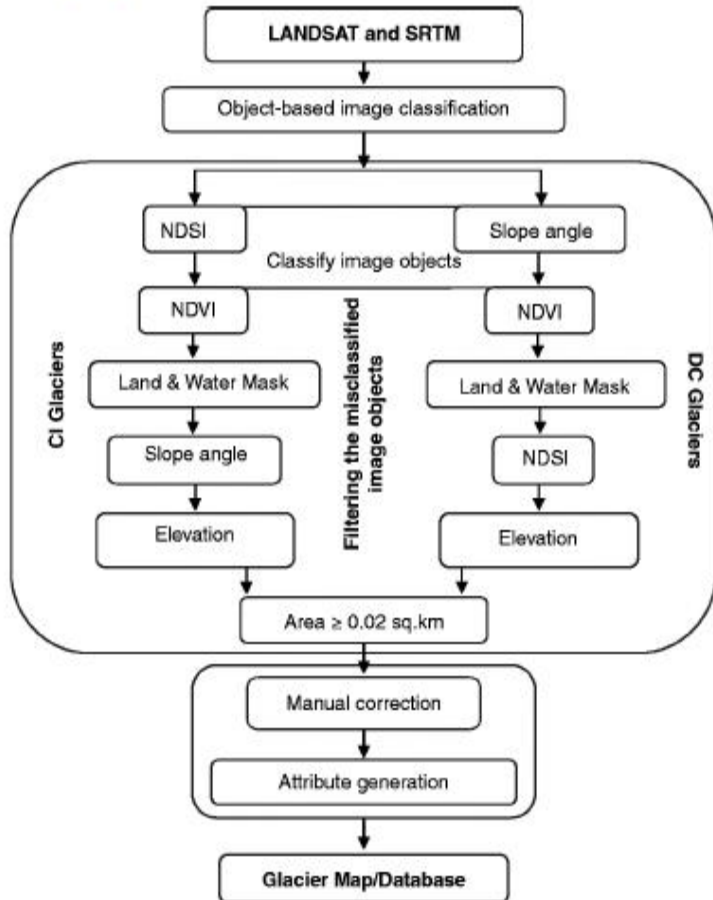
Water quality assessment

Table 3. Correlation coefficient analyses between water quality and spectral indices

Parameter	EC	pH	Nitrate	Nitrite	Silicate	Phosphate	O.M	NDSI	NDVI	NDBI	N/P ratio
EC	1										
pH	0.192	1									
Nitrate	0.106	0.173	1								
Nitrite	0.292	0.144	0.806	1							
Silicate	0.827	0.229	0.46	0.721	1						
Phosphate	-0.016	-0.353	-0.28	-0.069	-0.002	1					
O.M	-0.02	-0.339	-0.086	-0.185	-0.044	-0.03	1				
NDSI	-0.273	0.033	-0.416	-0.517	-0.272	-0.085	0.246	1			
NDVI	0.273	-0.033	0.416	0.517	0.272	0.085	-0.246	-1	1		
NDBI	-0.355	-0.006	-0.332	-0.516	-0.392	0.032	0.488	0.744	-0.744	1	
N/P ratio	-0.221	0.329	0.897	0.738	0.334	-0.171	-0.096	-0.345	0.345	-0.135	1.000

Source: Ahmed M. El-Zeiny, 2018

Application of snow indices



Source: Bajracharya et al., 2015

با تشکر از صبر و حوصله شما





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