Food and Agriculture Organization
of the United Nations

EMERGING INNOVATIONS IN IRRIGATION PERFORMANCE ASSESSMENT

Remote sensing techniques for irrigation performance assessment and benchmarking

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Regional gathering
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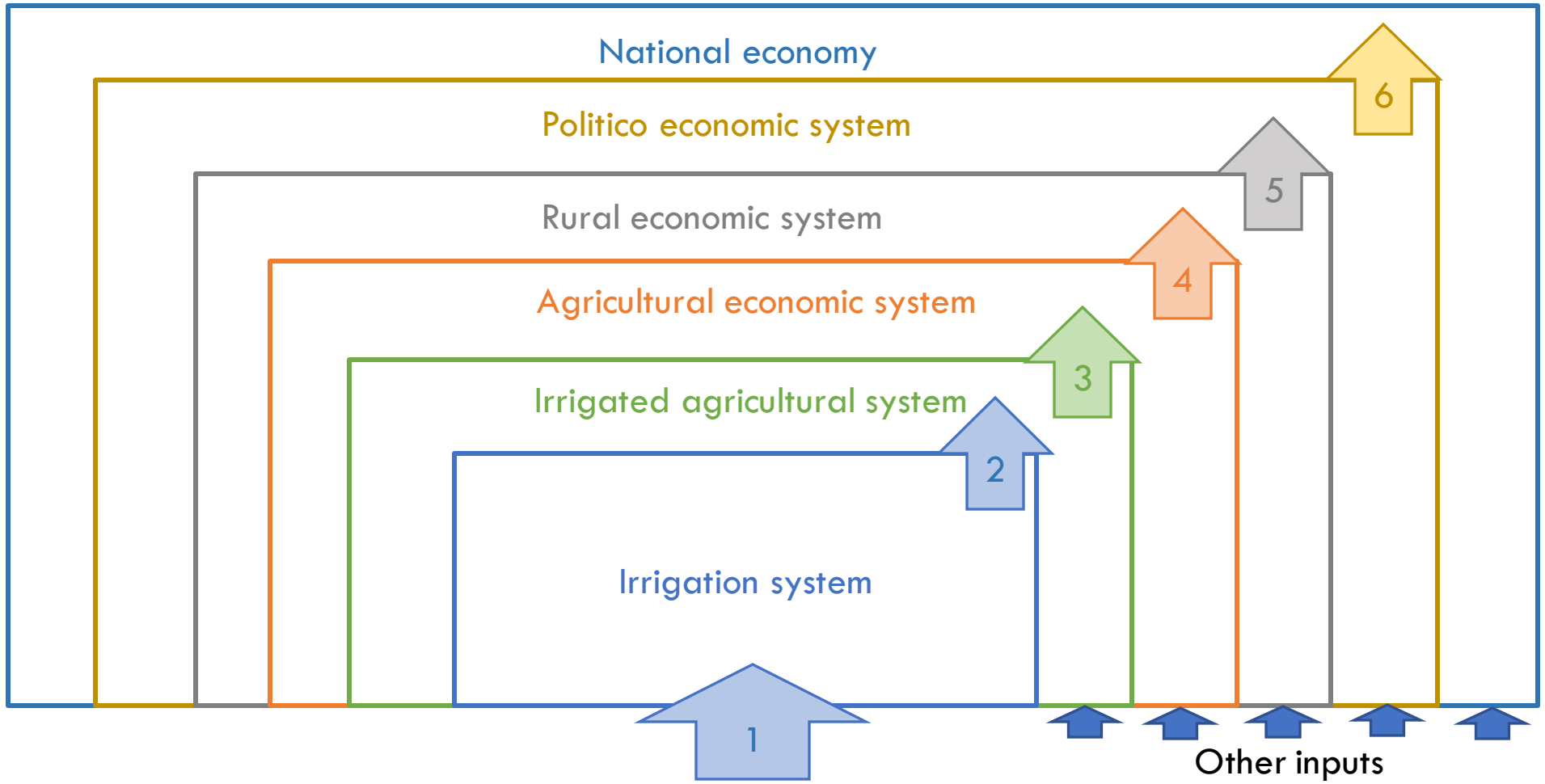
ITALIAN AGENCY FOR DEVELOPMENT COOPERATION

CONTENTS

- Importance of irrigated agriculture systems
- Performance indicators
- Tools and techniques used for performance assessment
- Review of Remote Sensing applications in irrigated agriculture
- Recommended resources for further studies

IMPORTANCE OF IRRIGATION SYSTEMS

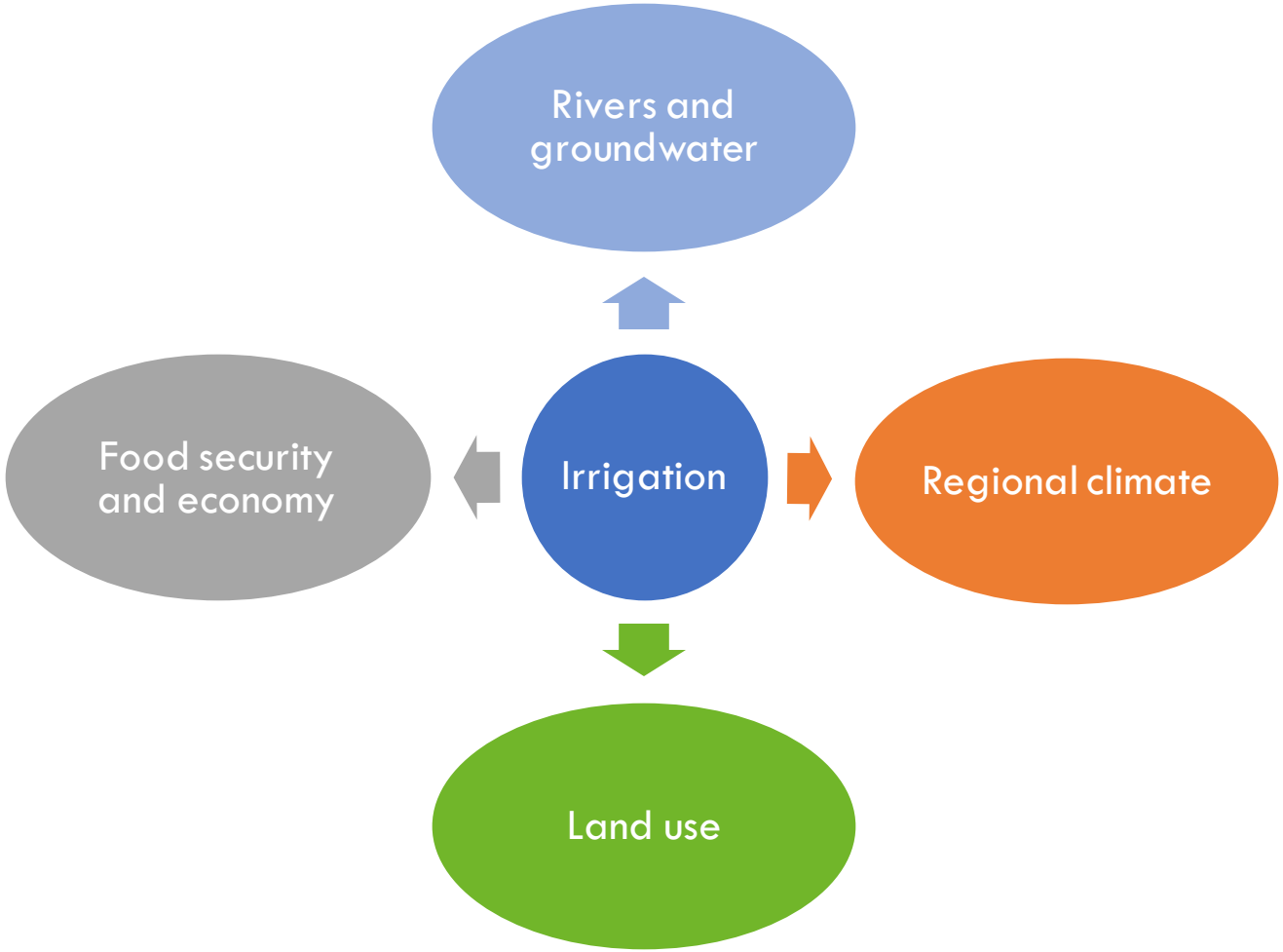


System inputs

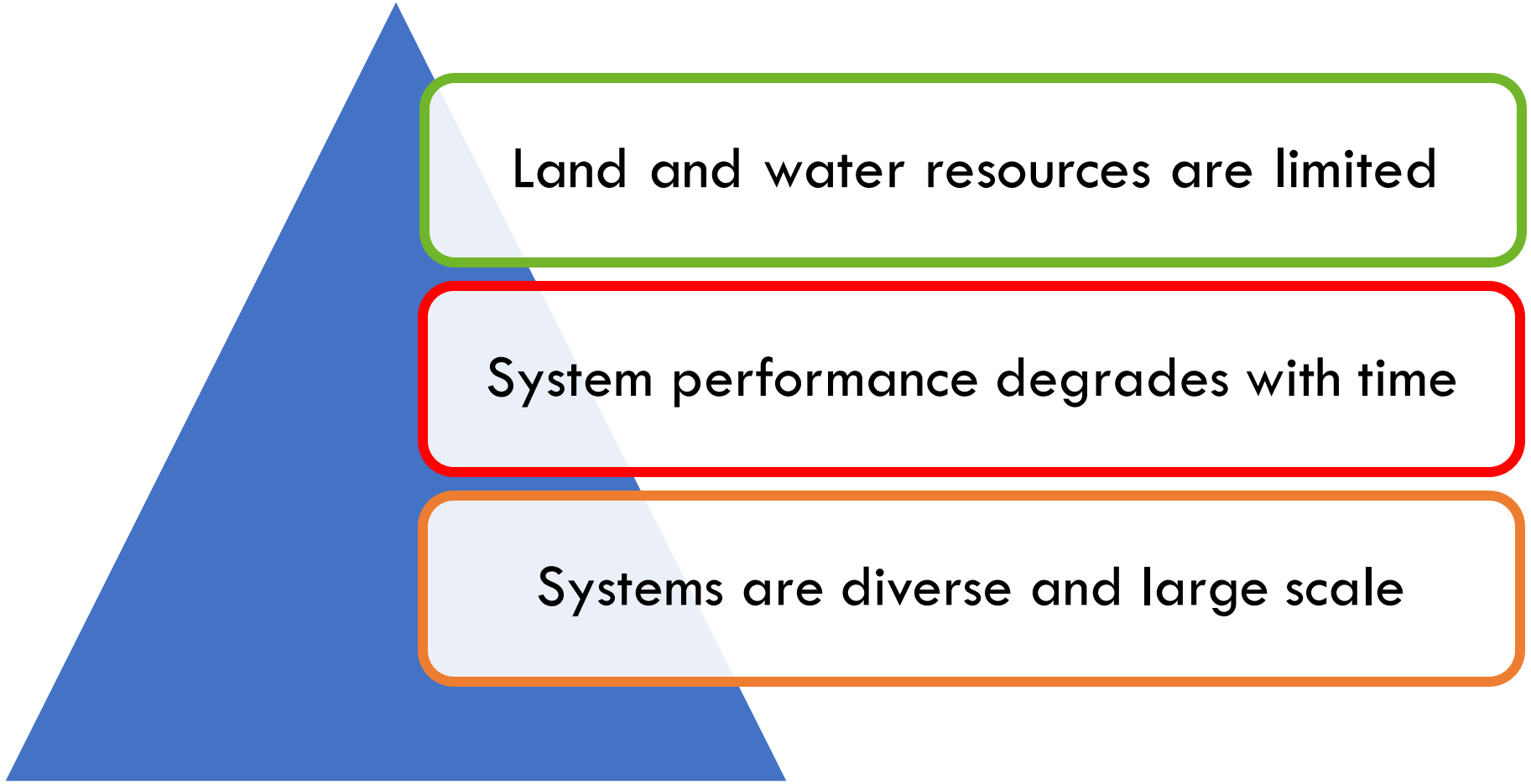
1 Irrigation operation
2 Water for crops
3 Agriculture production
4 Income in rural sector
5 Rural development
6 National development

Ref: (Small & Svendsen, 1992)

IMPACTS OF IRRIGATION



THE NEED OF PERFORMANCE ASSESSMENT



PERFORMANCE INDICATORS

- Irrigation related performance indicators
  - Benchmarking of irrigation infrastructure
  - Water resources monitoring
  - Water delivery functions (irrigation related
- Agriculture related performance indicators
  - Cropping pattern
  - Cropping intensity
  - Crop management

TOOLS AND TECHNIQUES USED FOR PERFORMANCE ASSESSMENT

Performance of irrigated agriculture can be assessed with several techniques and methods, such as

Method and Tool	Pros and cons
Direct measurements for performance indicators	Extensive field measurement data intensive and small scale
Analytical methods (examples are AHP and fuzzy set theory)	Computational complexity, data intensive and small scale
Remotely sensed performance indicators	Low complexity, highly scalable, higher measurement frequency, readily available data, low cost

REVIEW OF REMOTE SENSING APPLICATIONS IN IRRIGATED AGRICULTURE

BENCHMARKING OF IRRIGATION INFRASTRUCTURE

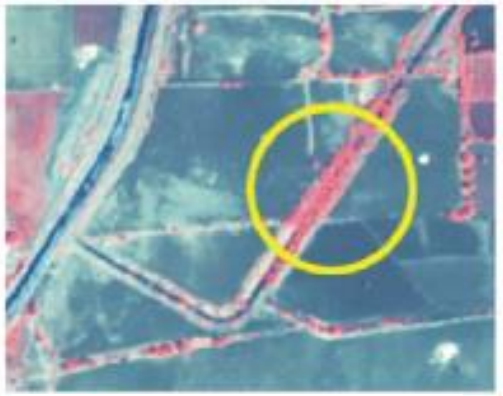
Objective: Remote methods can be used to evaluate the construction progress of designed canal length and other irrigation and drainage infrastructure.

Data and methods
Multi spectral satellite images (NIR, R bands)
NDVI map of project area

Data sources: USGS Earth Explorer, ESA Copernicus Open Access Hub, NASA Earth Data Search, DigitalGlobe Open Data Program, +++.
Analysis tool: Open-source RS/GIS software: (QGIS), Sentinel Toolbox, SAGA GIS, GRASS, PolSARPro, +++.

Main canal offtake

Distributary offtake



Lateral covered with vegetation

Pipe outlet

Pending construction

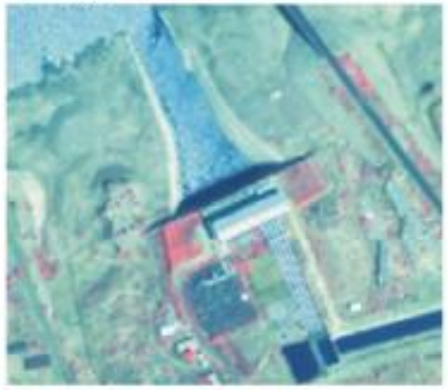
Pending structure

Babu et al., 2012. Satellite derived geospatial irrigation performance indicators for benchmarking studies of irrigation systems. Cited 5 Dec 2022.

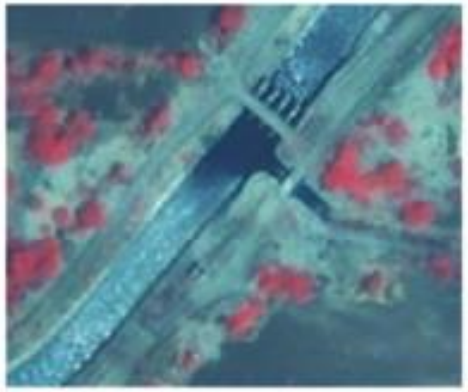
BENCHMARKING OF IRRIGATION INFRASTRUCTURE

Progress monitoring on irrigation development

Regulators



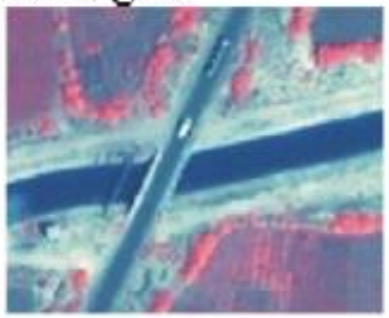
Head Regulator



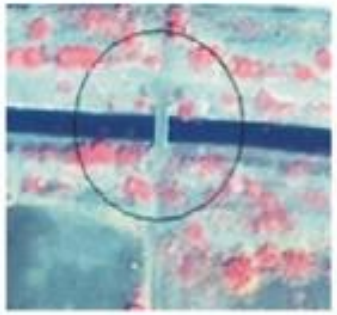
Cross Regulator

Escape Regulator

Bridges



Road bridge

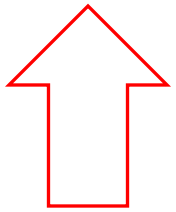


Foot/Cart bridge

Super passages

WHY VEGETATION APPEARS DISTINCT IN NDVI MAP?

Healthy vegetation



NIR

RED

Large NIR effect

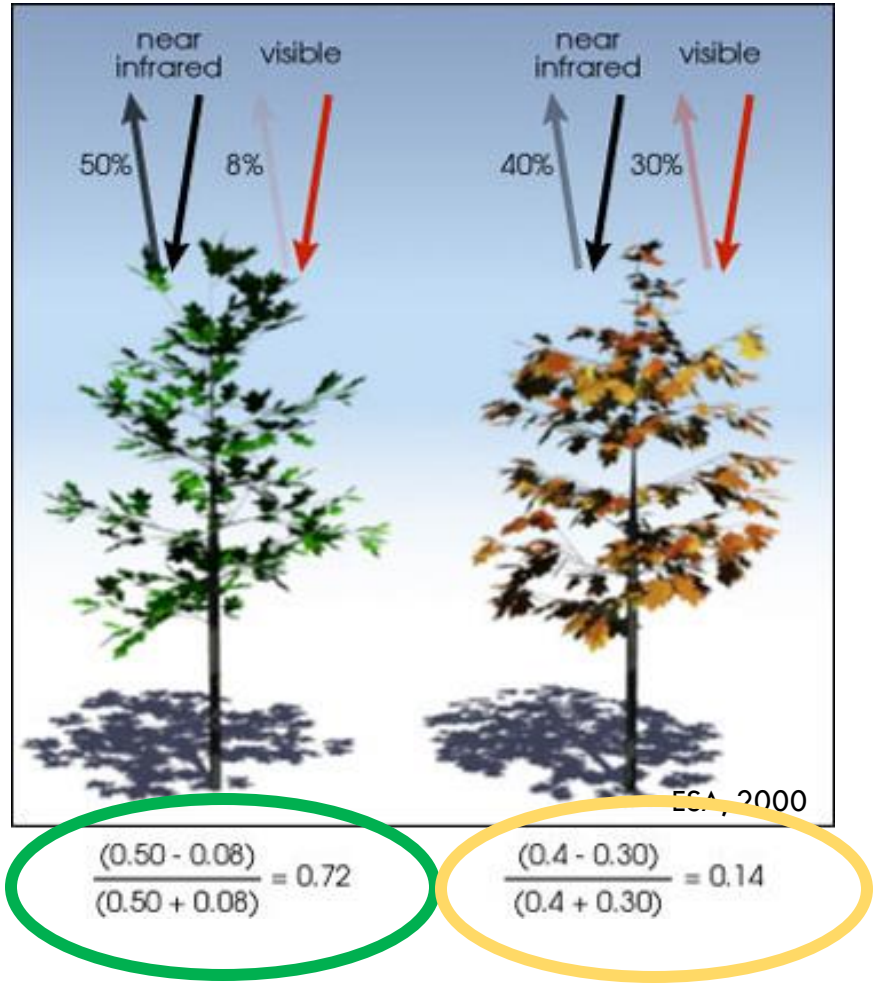
Unhealthy vegetation

NIR

RED

Comparable effect

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



REMOTE MONITORING OF RESERVOIR STORAGE

Objective: Remote monitoring of water storage in irrigation reservoir prior to the cropping season helps in decision making on the choice of crops and area to be cultivated during the next season.

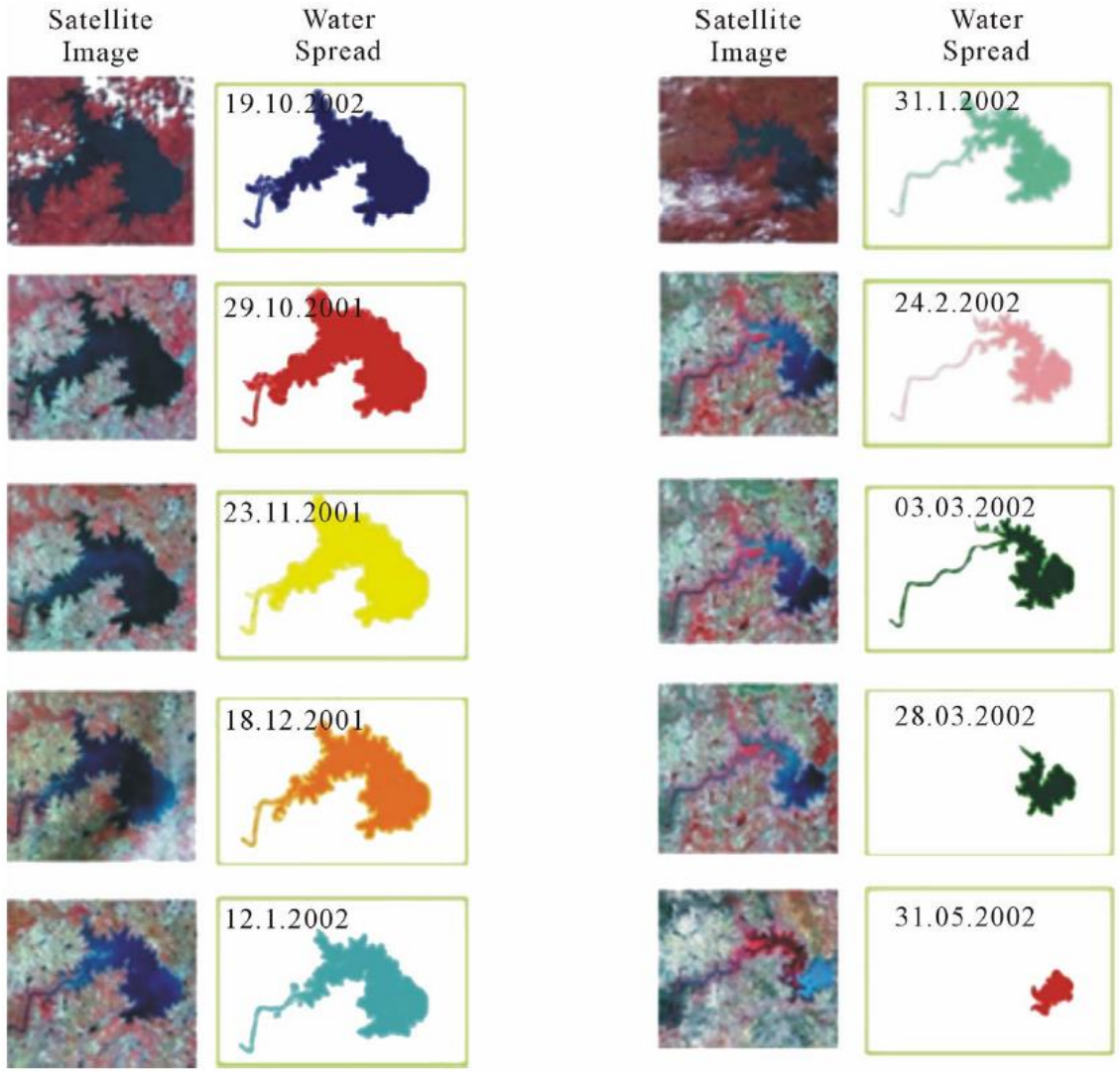
Data and methods

Multi spectral satellite images (NIR, G bands) OR Synthetic Aperture Radar (SAR) imagery (Day night observation).

NDWI map of reservoir or Water area mask using SAR

Data sources: USGS Earth Explorer, ESA Copernicus Open Access Hub, NASA Earth Data Search, DigitalGlobe Open Data Program, +++.

Analysis tool: Open-source RS/GIS software: (QGIS), Sentinel Toolbox, SAGA GIS, GRASS, PolSARPro, +++.



Babu et al., 2012. Satellite derived geospatial irrigation performance indicators for benchmarking studies of irrigation systems. Cited 5 Dec 2022.

REMOTE MONITORING OF RESERVOIR SEDIMENTATION

Objective: Remote sensing methods can be used to monitor sediments deposition in the reservoirs and how the capacity of reservoir is reduced.

Data and methods

Multi spectral satellite images (NIR, G bands)

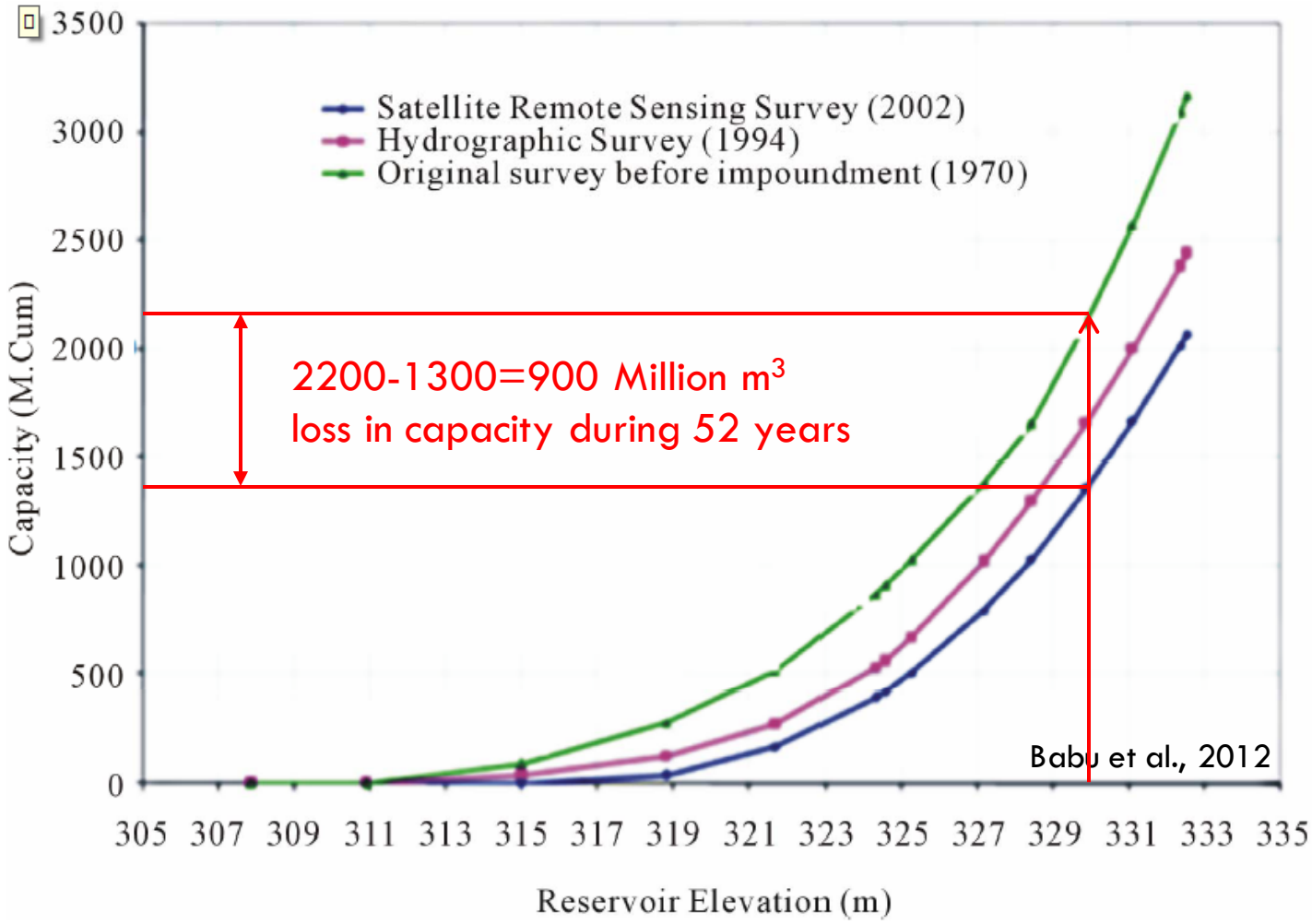
OR

Synthetic Aperture Radar (SAR) imagery (Day night observation).

NDWI map of reservoir or Water area mask using SAR

Data sources: USGS Earth Explorer, ESA Copernicus Open Access Hub, NASA Earth Data Search, DigitalGlobe Open Data Program, +++.

Analysis tool: Open-source RS/GIS software: (QGIS), Sentinel Toolbox, SAGA GIS, GRASS, PolSARPro, +++.



DISCHARGE MONITORING INTO RESERVOIRS

Objective: Remote monitoring of river discharge

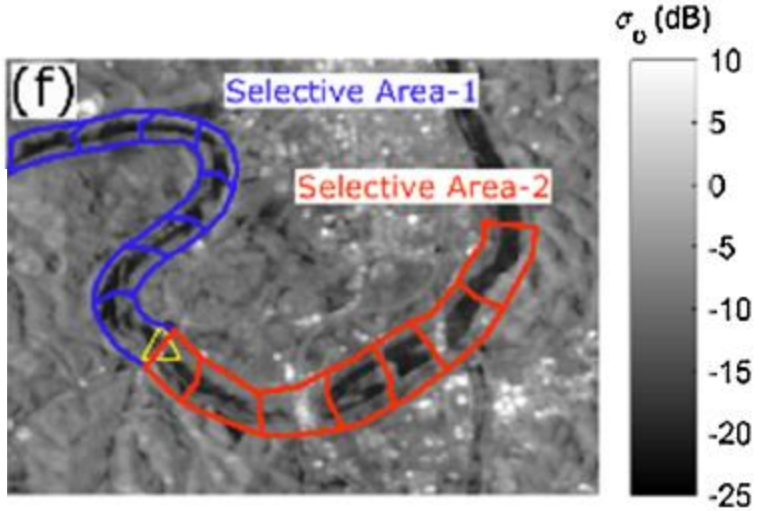
Data and methods

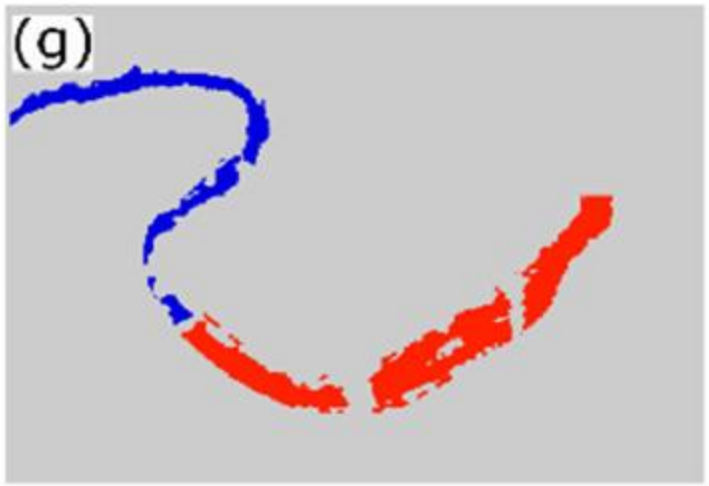
Synthetic Aperture Radar (SAR) imagery (observation during day-night and all-weather condition).

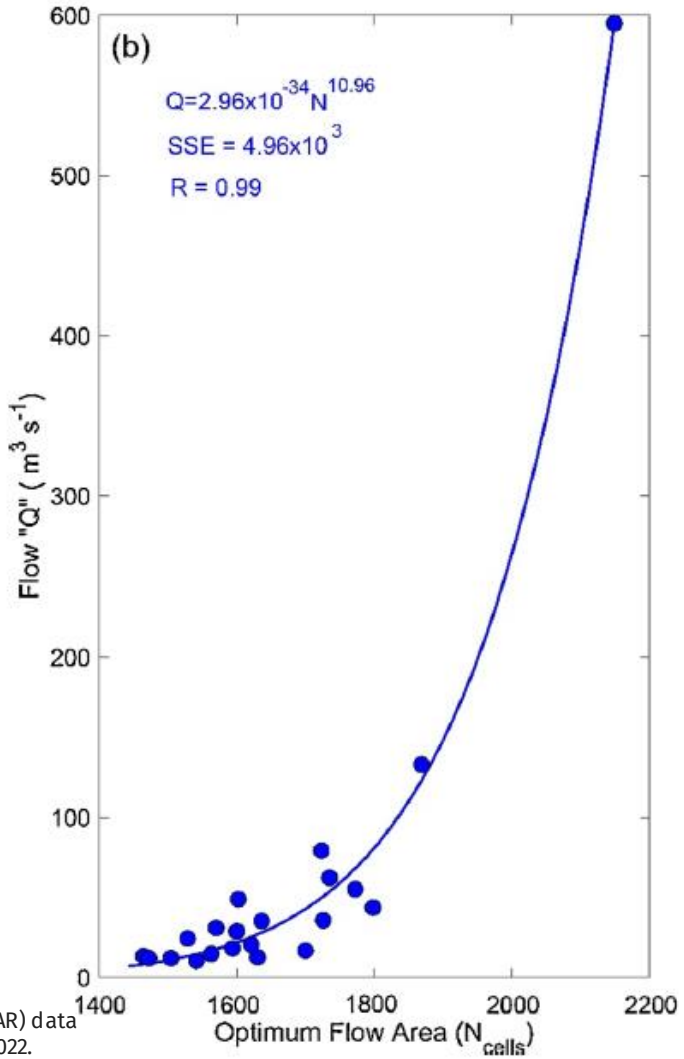
Water area mask using thresholding of SAR images

Data sources: ESA Sentinel Open Access Hub.

Analysis tool: Open-source RS/GIS software: Sentinel Toolbox.







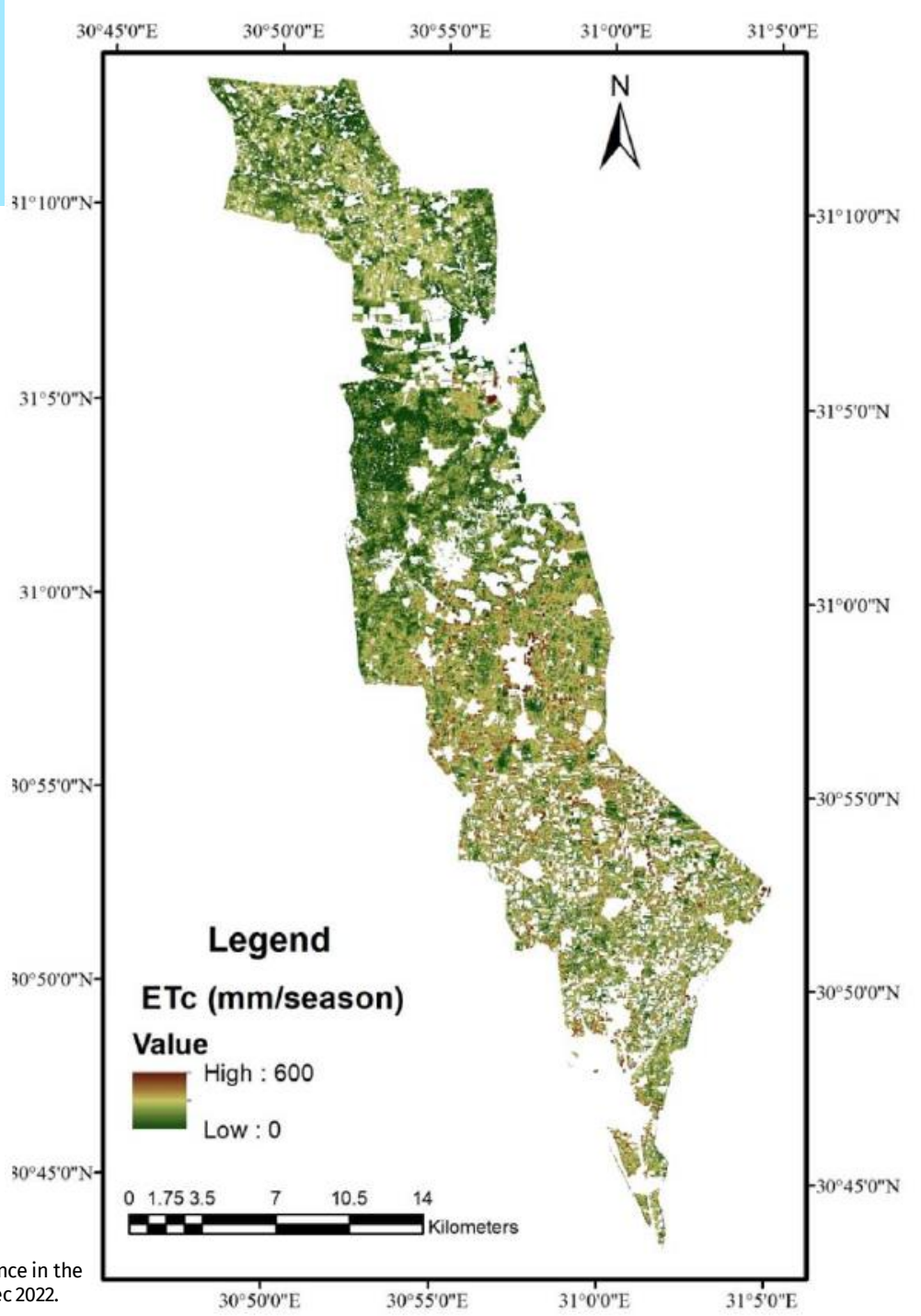
Ahmad, W., & Kim, D., 2019. Estimation of flow in various sizes of streams using the Sentinel-1 Synthetic Aperture Radar (SAR) data in Han River Basin, Korea. *International Journal of Applied Earth Observation and Geoinformation*, *83*, 101930. Cited 5 Dec 2022.

IRRIGATION PERFORMANCE ASSESSMENT

Objective: Remote sensing is widely used to assess the performance of irrigation systems using different indicators i.e NDVI, ETc, NDWI, biomass growth, moisture deficit and soil moisture etc.

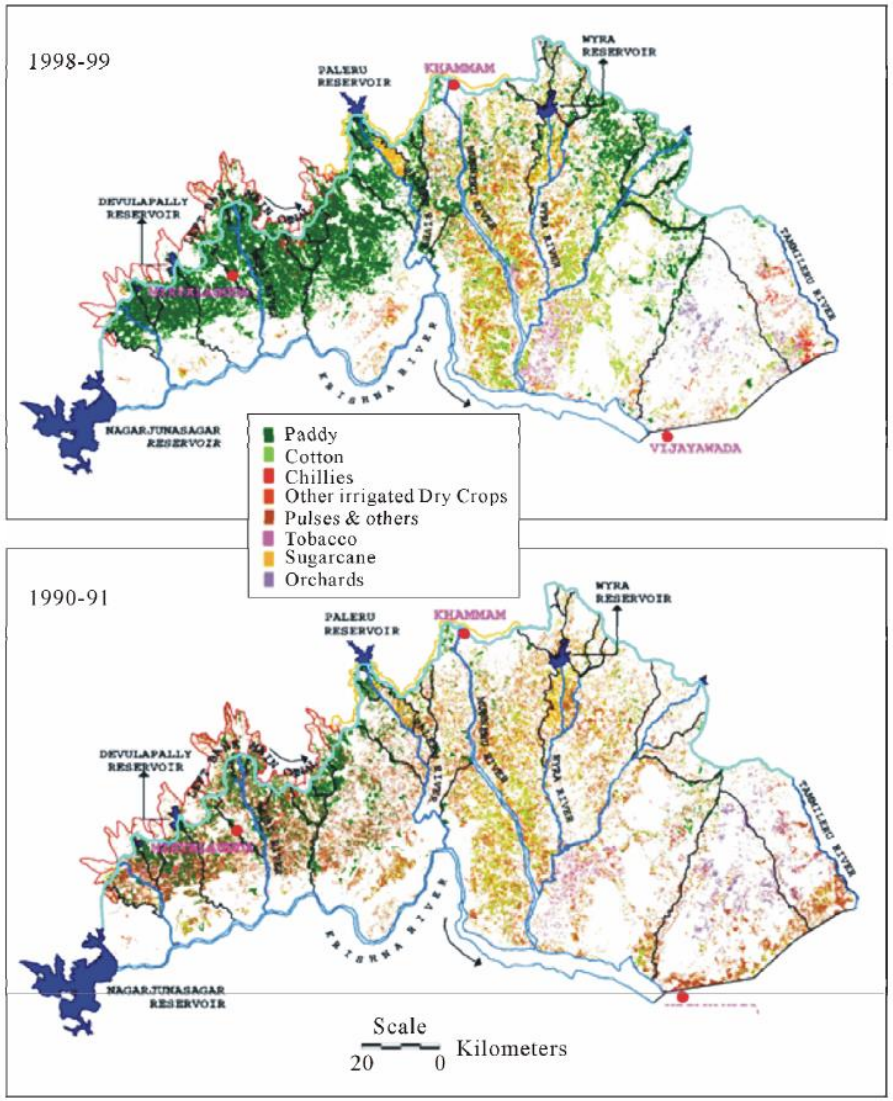
Data and methods
Multi spectral satellite images of LandSAT 8.
Surface Energy balance model (SEBAL) to compute ETc OR
Data sources: USGS Earth Explorer

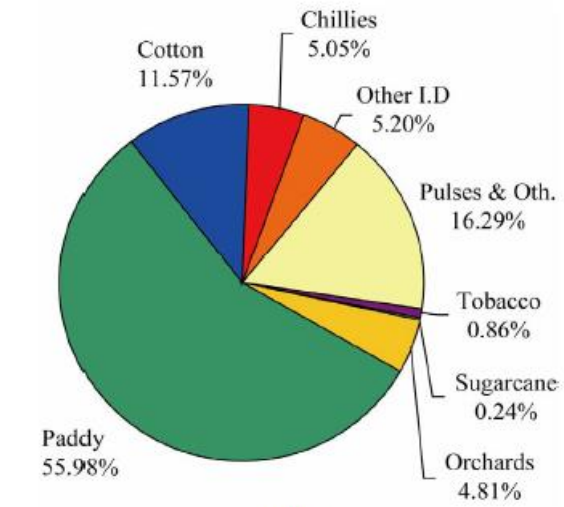
Analysis tool: Open-source RS/GIS software: (QGIS), SAGA GIS, GRASS, PolSARPro, +++.



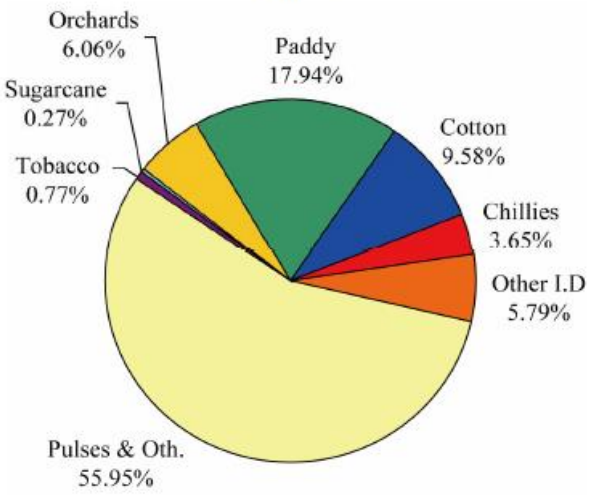
Source: Elnmer et al., 2018. Assessment of irrigation water performance in the Nile delta using remotely sensed data. *Water*, *10*(10), 1375. Cited 5 Dec 2022.

REMOTE ASSESSMENT OF CROPPING PATTERN





1998-99



Babu et al., 2012. Satellite derived geospatial irrigation performance indicators for benchmarking studies of irrigation systems. Cited 5 Dec 2022.

CROP MANAGEMENT

Objective: Assessment of canopy cover and Relative Nitrogen Content (GNDVI) in paddy fields to identify critical zones for better crop management

Data and methods

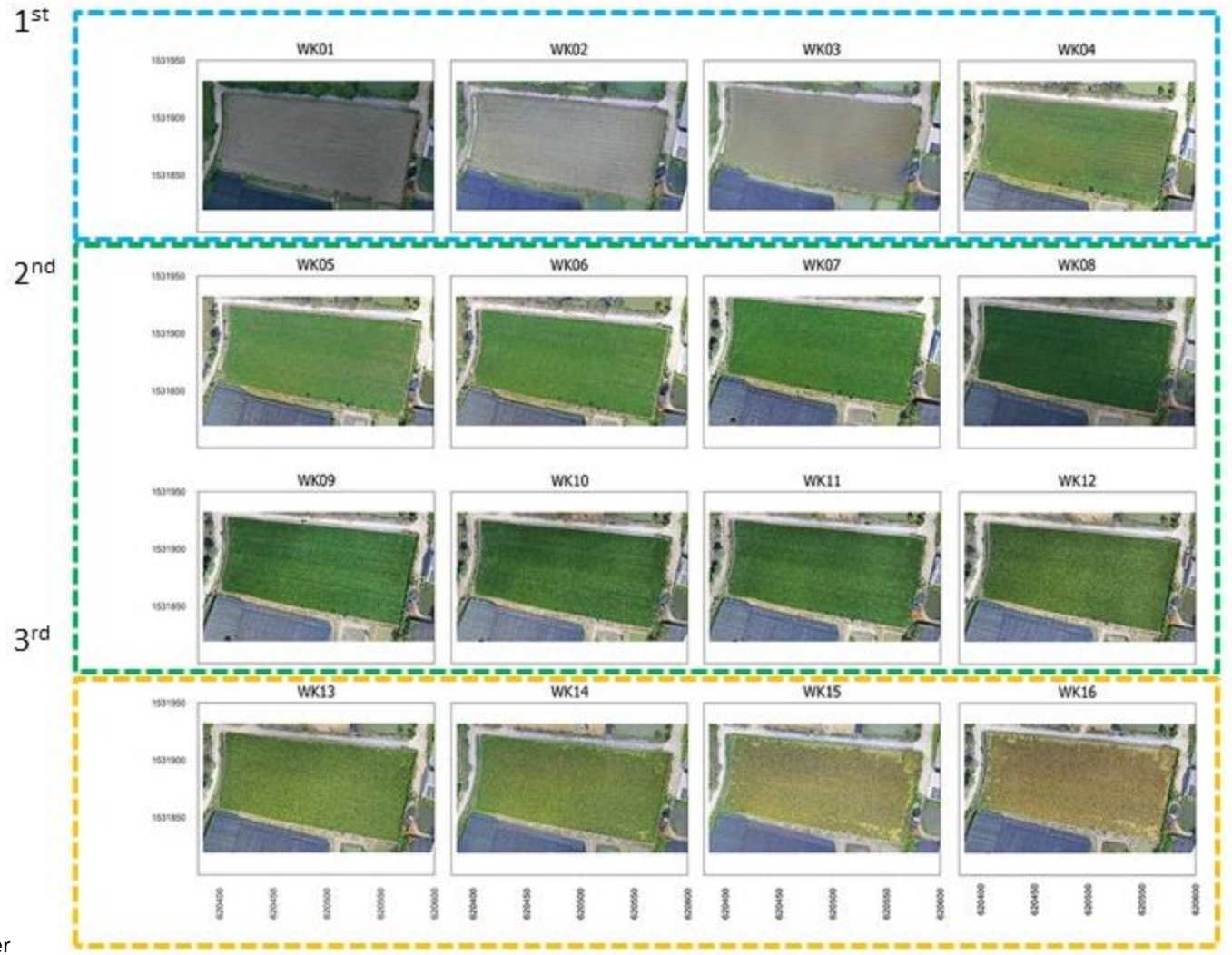
Multi spectral images of various EOS and UAV can be used.

NDVI, Green NDVI (GNDVI), and Triangular Greeness Index (TGI)

Data sources: ESA Sentinel Open Access Hub, and UAV.

Analysis tool: Open-source RS/GIS software: Sentinel Toolbox, QGIS

Weekly images of paddy field (10mx10m)

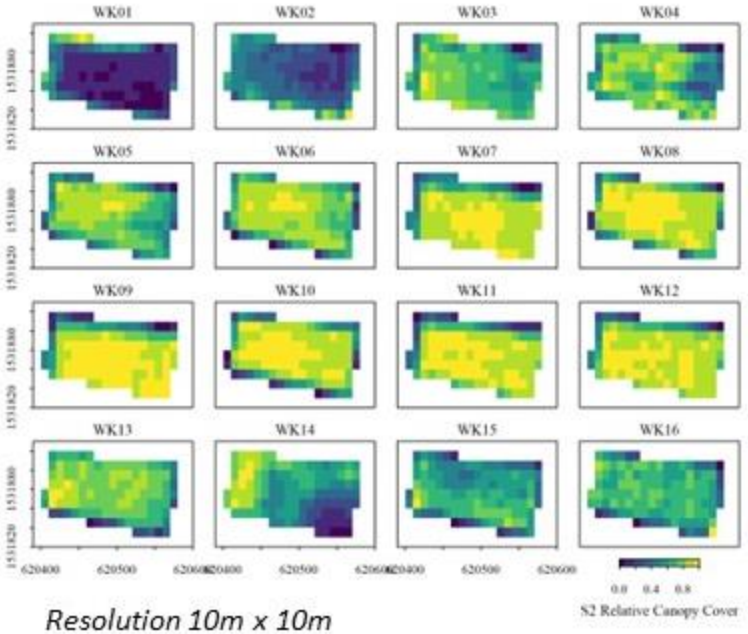


UAV orthomoseic of 16 weeks.

Waruth et al., 2022.). Application of UAVs to Monitor Paddy Crop Growth, Chlorophyll, and Nitrogen Content for Informed Decision Making in Water and Nutrient Management. Thesis, Water Engineering and Management (WEM), Asian Institute of Technology (AIT), Thailand. Cited 5 Dec 2022.

CROP MANAGEMENT

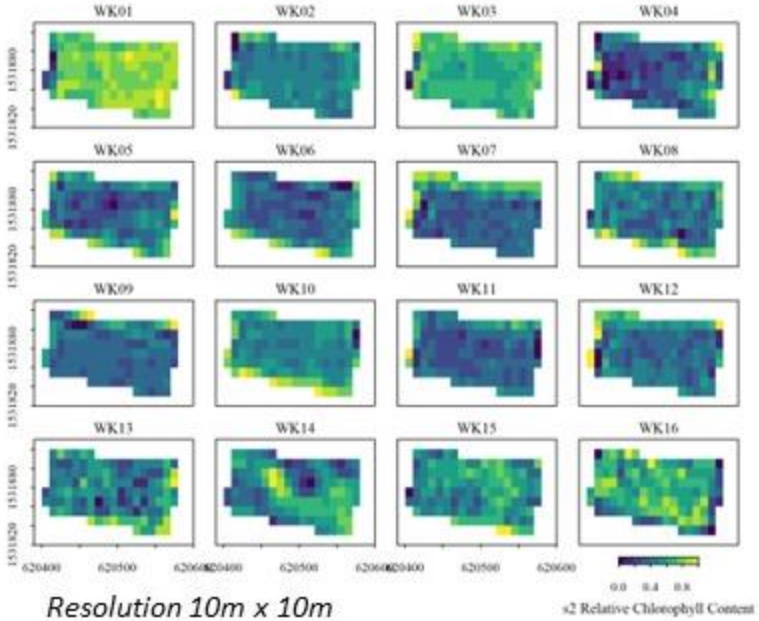
Chlorophyll content



Resolution 10m x 10m

$$CC = \frac{(NDVI - NDVI_{min})}{(NDVI_{max} - NDVI_{min})}$$

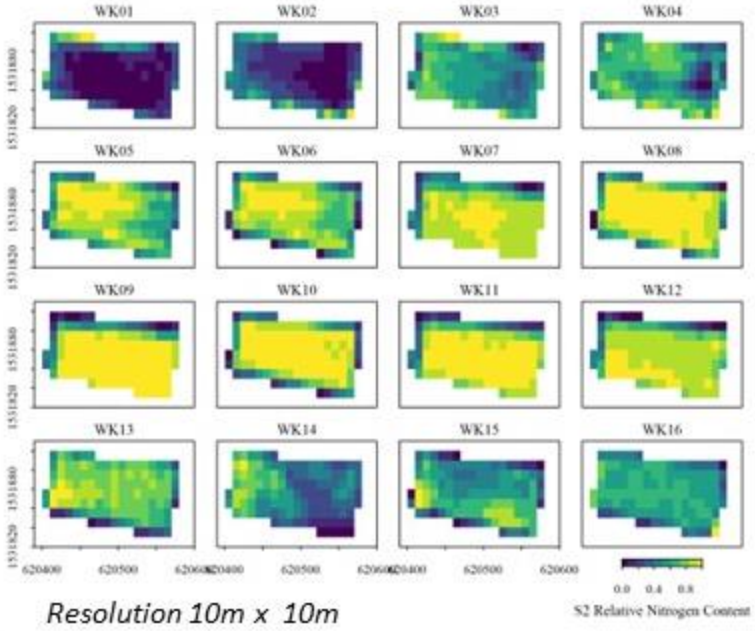
Relative Chlorophyll Content (TGI)



Resolution 10m x 10m

$$Relative\ Chl = \frac{(TGI - TGI_{min})}{(TGI_{max} - TGI_{min})}$$

Relative Nitrogen Content (GNDVI)

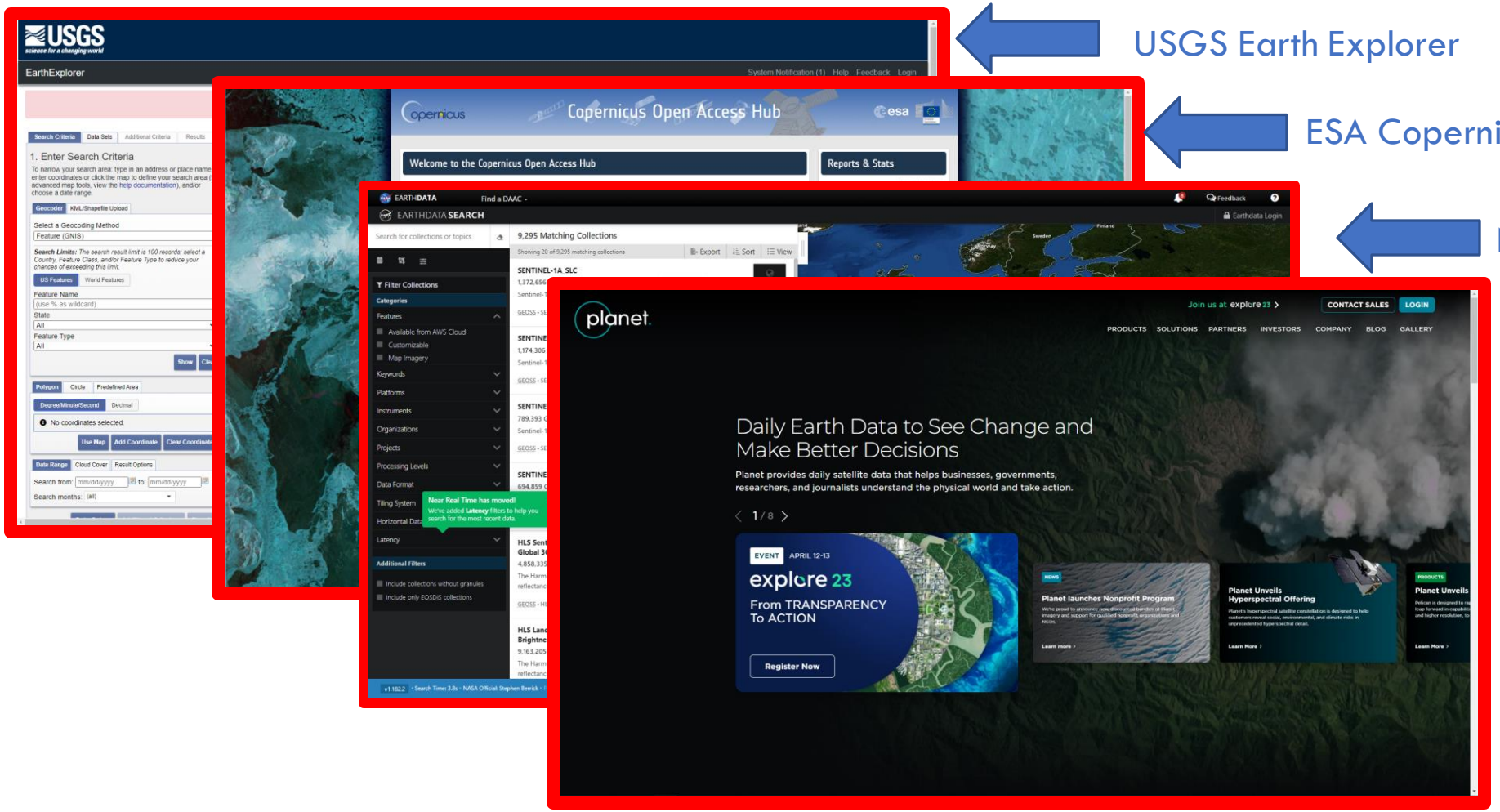


Resolution 10m x 10m

$$Relative\ N = \frac{(GNDVI - GNDVI_{min})}{(GNDVI_{max} - GNDVI_{min})}$$

*Triangular greenness index

REMOTE SENSING DATA RESOURCES



USGS Earth Explorer

ESA Copernicus Open Access Hub

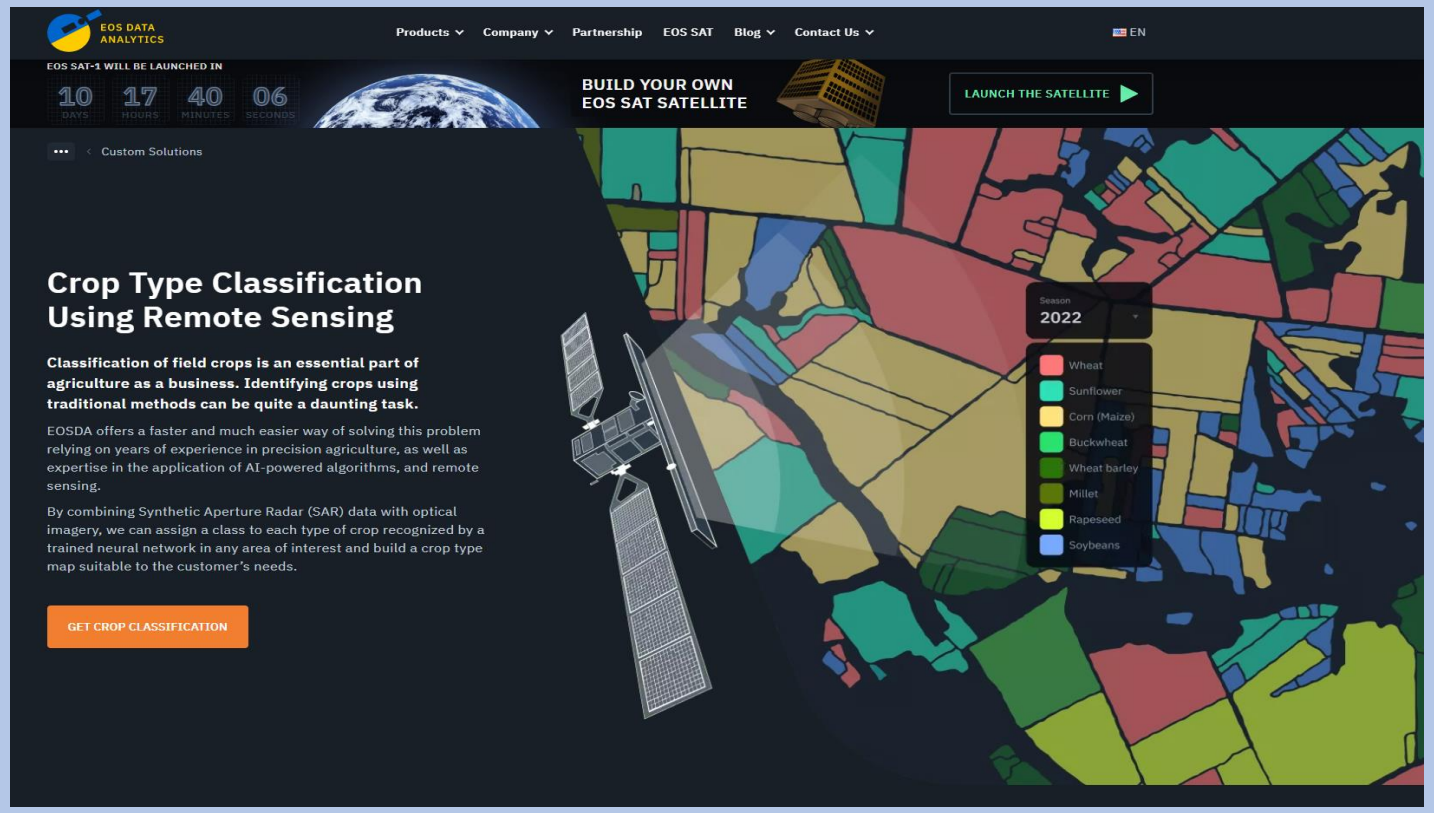
NASA Earth Data

PlanetLab

ONLINE READY TO USE RESOURCE

Earth Observation Satellite (EOS) Data Analytics https://eos.com/

Products: Crop monitoring, Forest monitoring, yield prediction, crop classification and harvest dynamics



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THANK YOU