



Food and Agriculture Organization
of the United Nations

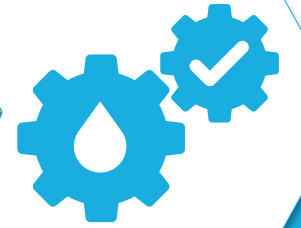
EMERGING INNOVATIONS IN IRRIGATION PERFORMANCE ASSESSMENT

Remote sensing techniques for irrigation performance assessment
and benchmarking

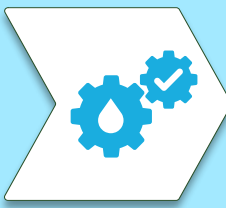
Waqas Ahmad

Land and Water Division (NSL), FAO
Tunis, 13 December 2022

Regional gathering
Tunis, 12 – 16 December 2022

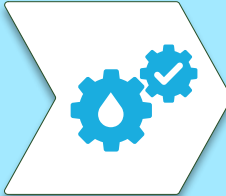


ITALIAN AGENCY
FOR DEVELOPMENT
COOPERATION

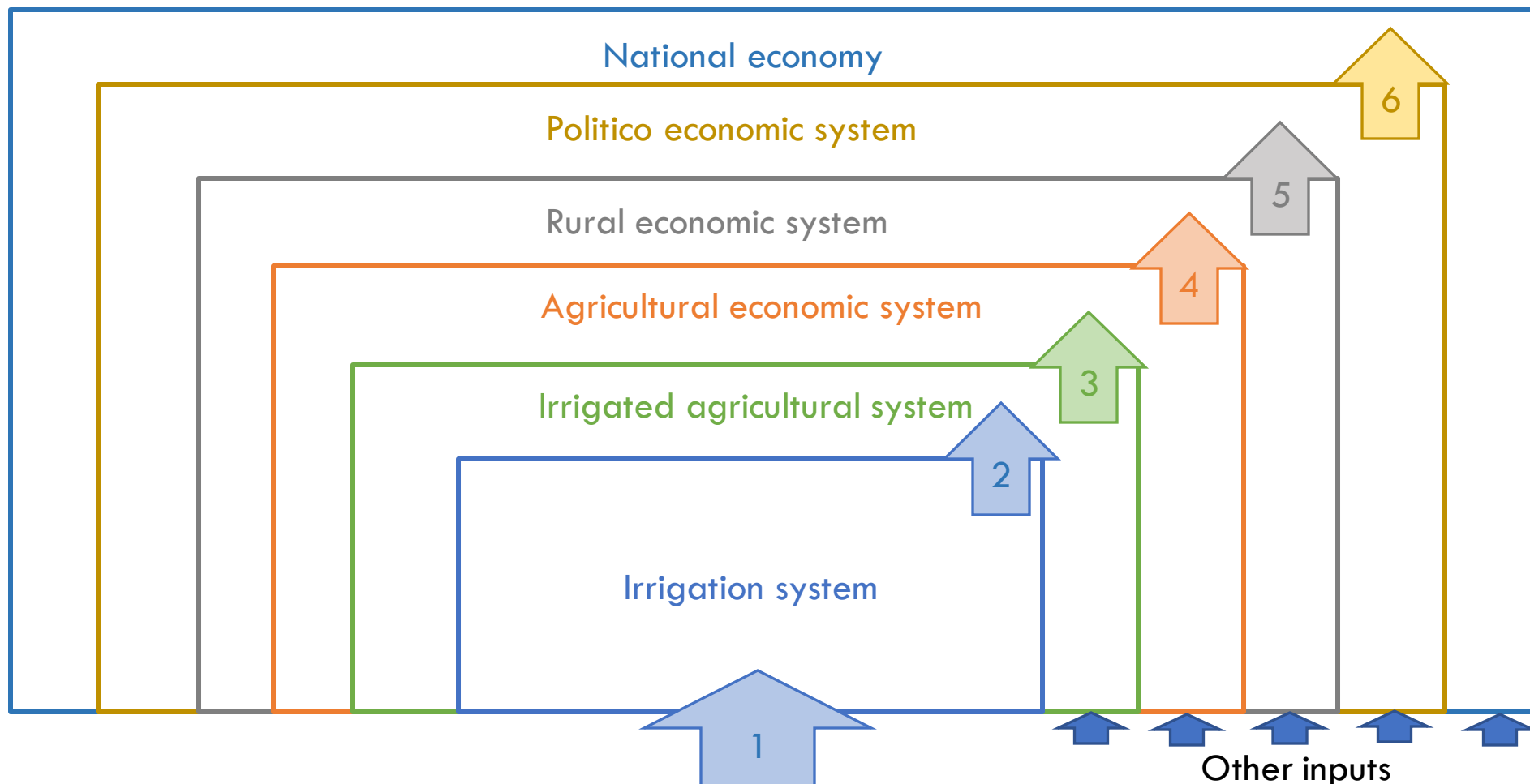


CONTENTS

- **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



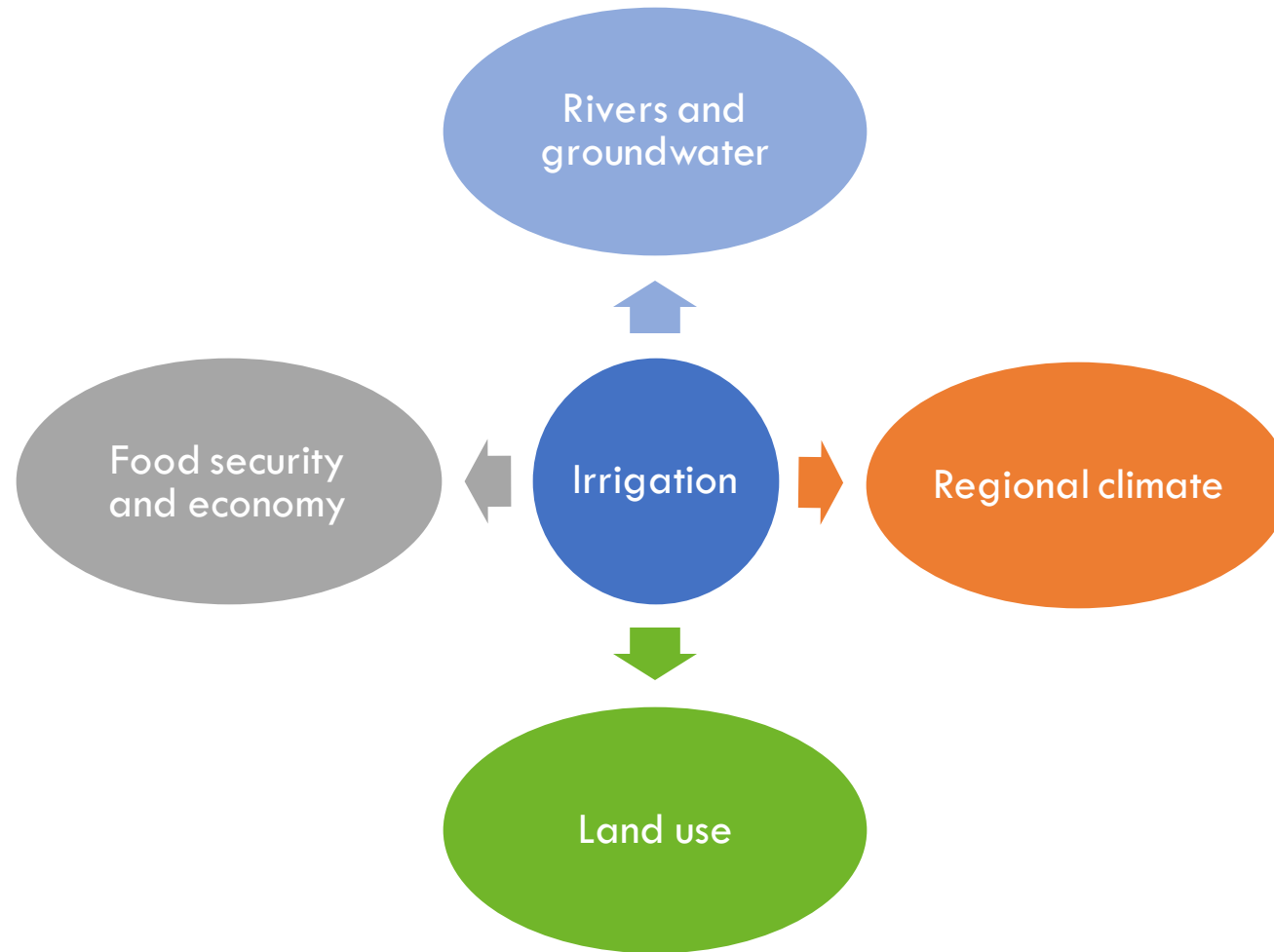
System inputs

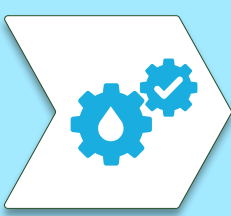
- 1 Irrigation operation
- 2 Water for crops
- 3 Agriculture production
- 4 Income in rural sector
- 5 Rural development
- 6 National development

Ref: (Small & Svendsen, 1992)



IMPACTS OF IRRIGATION



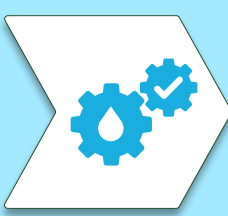


THE NEED OF PERFORMANCE ASSESSMENT

Land and water resources are limited

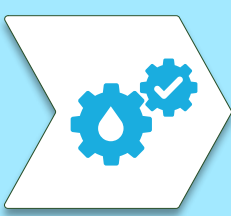
System performance degrades with time

Systems are diverse and large scale



PERFORMANCE INDICATORS

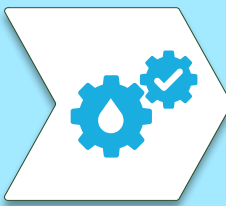
- ❑ Irrigation related performance indicators
 - Benchmarking of irrigation infrastructure
 - Water resources monitoring
 - Water delivery functions (irrigation related)
- ❑ Agriculture related performance indicators
 - Cropping pattern
 - Cropping intensity
 - Crop management



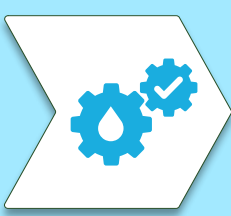
TOOLS AND TECHNIQUES USED FOR PERFORMANCE ASSESSMENT

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, +++.

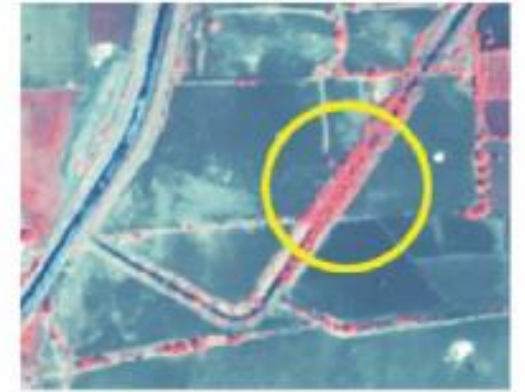
Analysis tool: Open-source RS/GIS software: (QGIS), Sentinel Toolbox, SAGA GIS, GRASS, PolSARPro, +++.



Main canal offtake



Distributary offtake



Lateral covered with vegetation



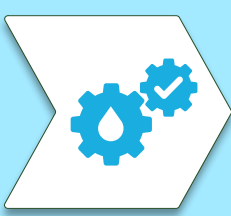
Pipe outlet



Pending construction



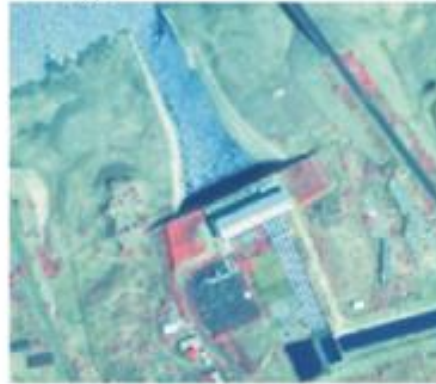
Pending structure



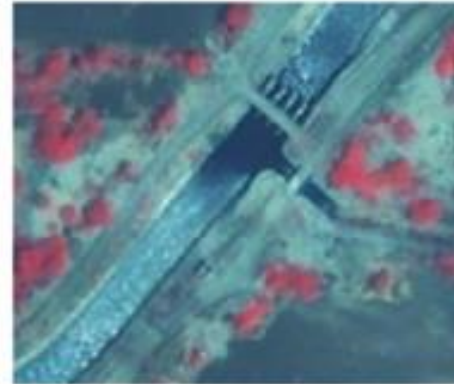
BENCHMARKING OF IRRIGATION INFRASTRUCTURE

Progress monitoring on irrigation development

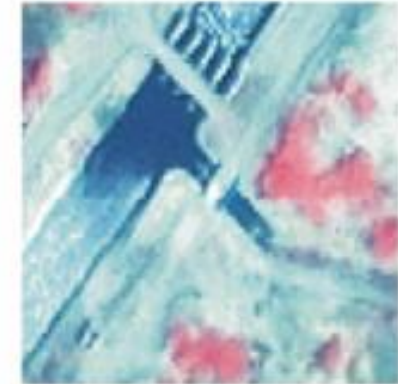
Regulators



Head Regulator



Cross Regulator

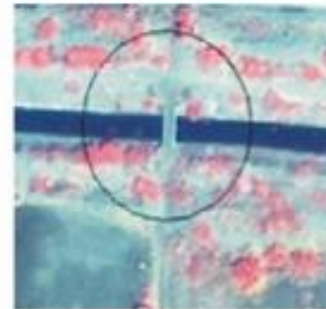


Escape Regulator

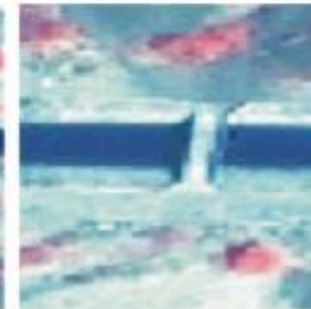
Bridges



Road bridge

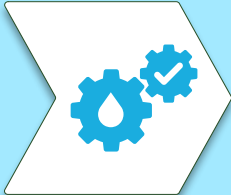


Foot/Cart bridge

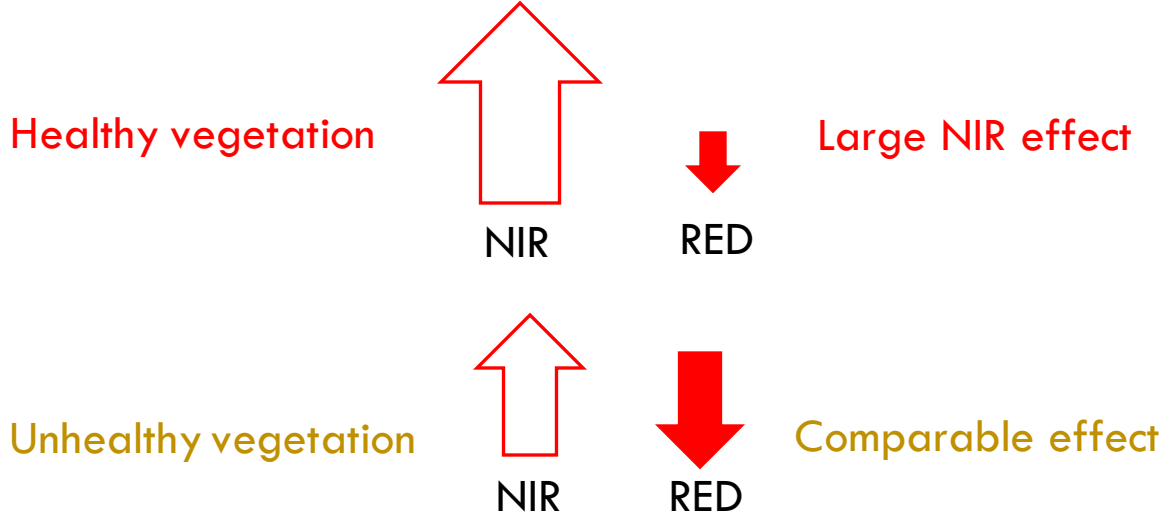


Super passages

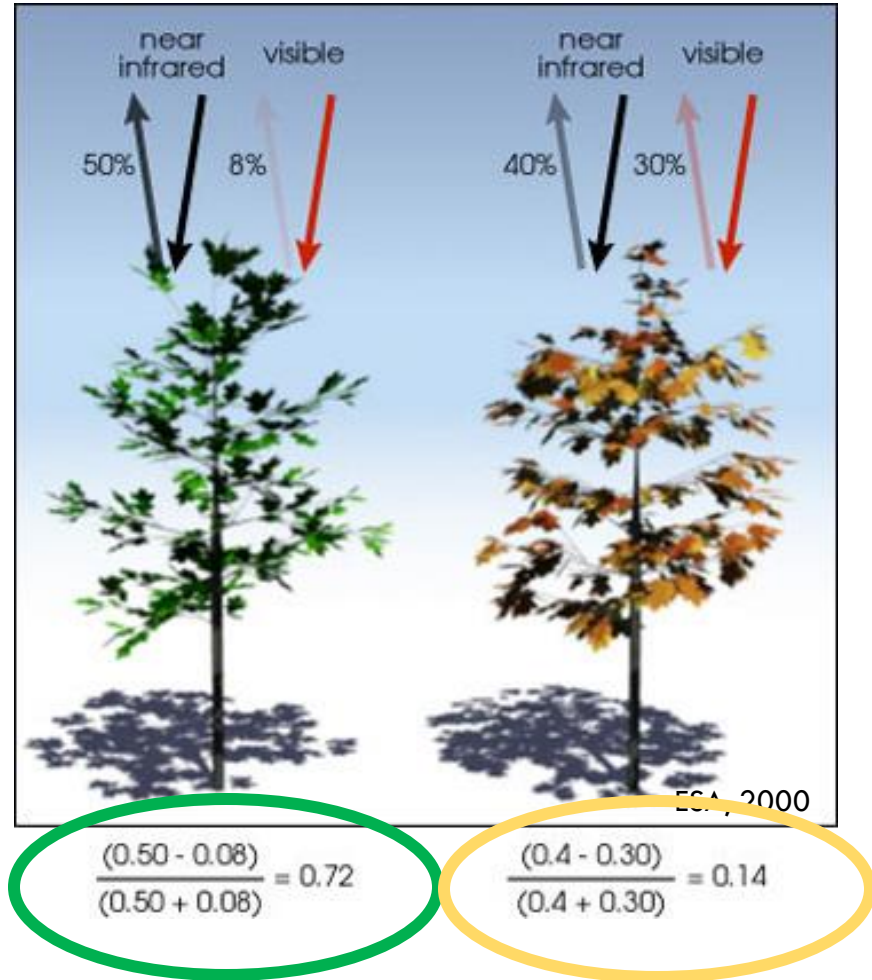


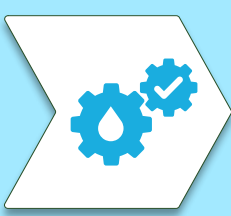


WHY VEGETATION APPEARS DISTINCT IN NDVI MAP?



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





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.

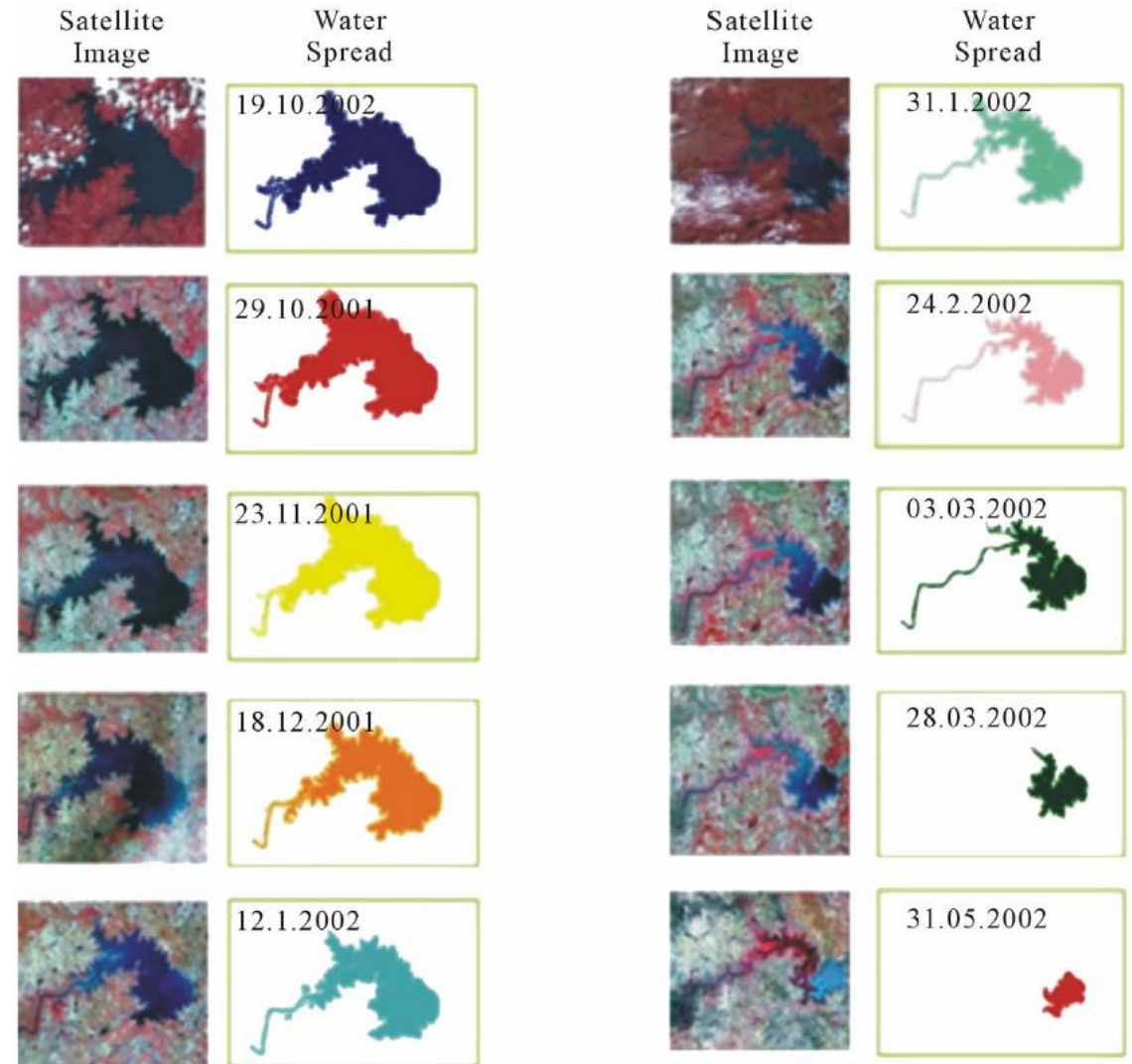
Data and methods

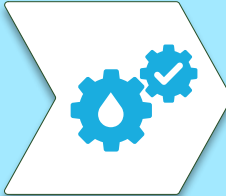
Multi spectral satellite images (NIR, G bands) OR Synthetic Aperture Radar (SAR) imagery (Day night observation).

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, +++.





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)

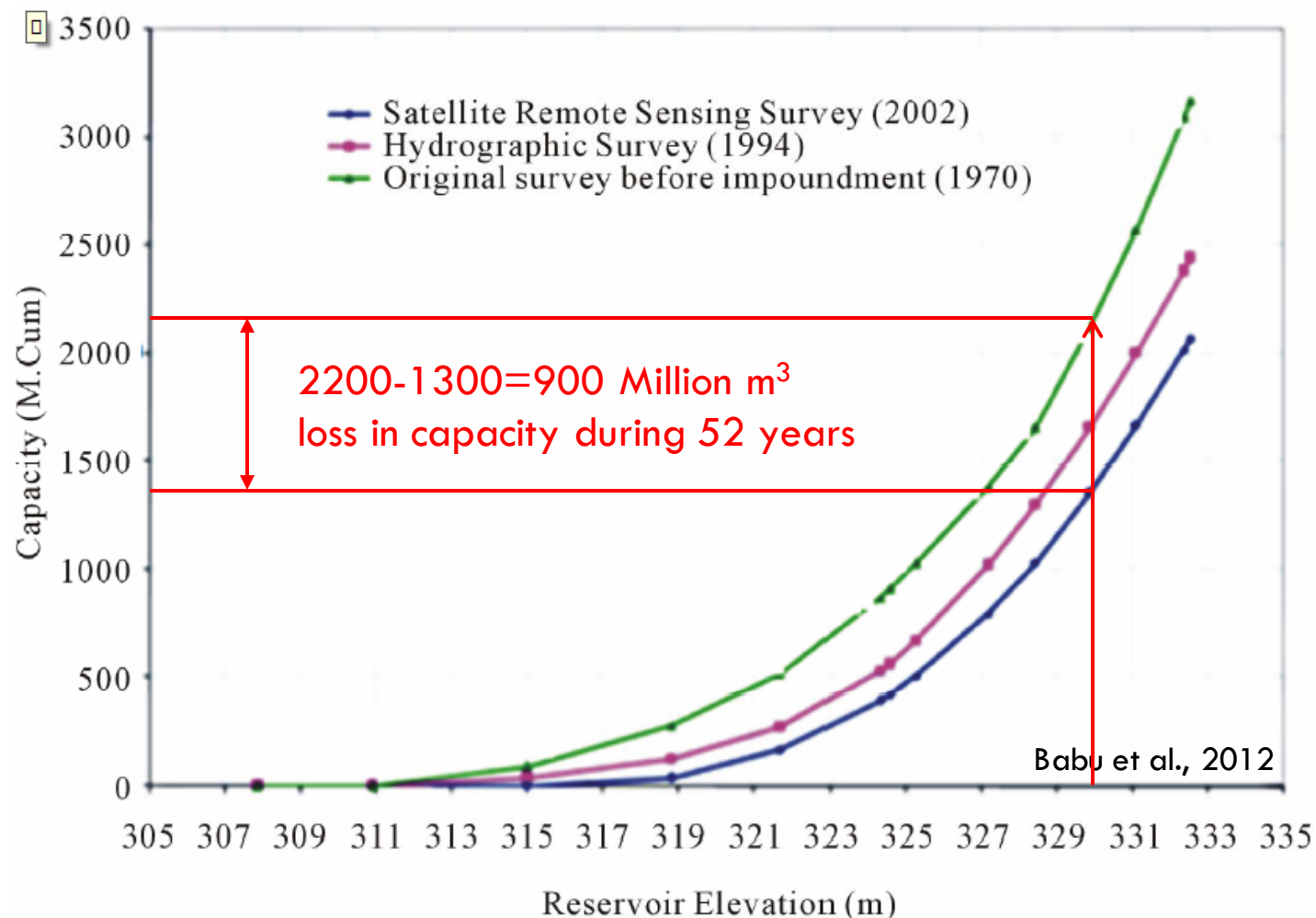
OR

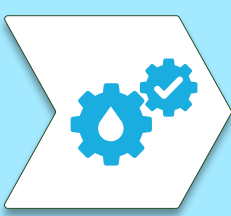
Synthetic Aperture Radar (SAR) imagery (Day night observation).

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

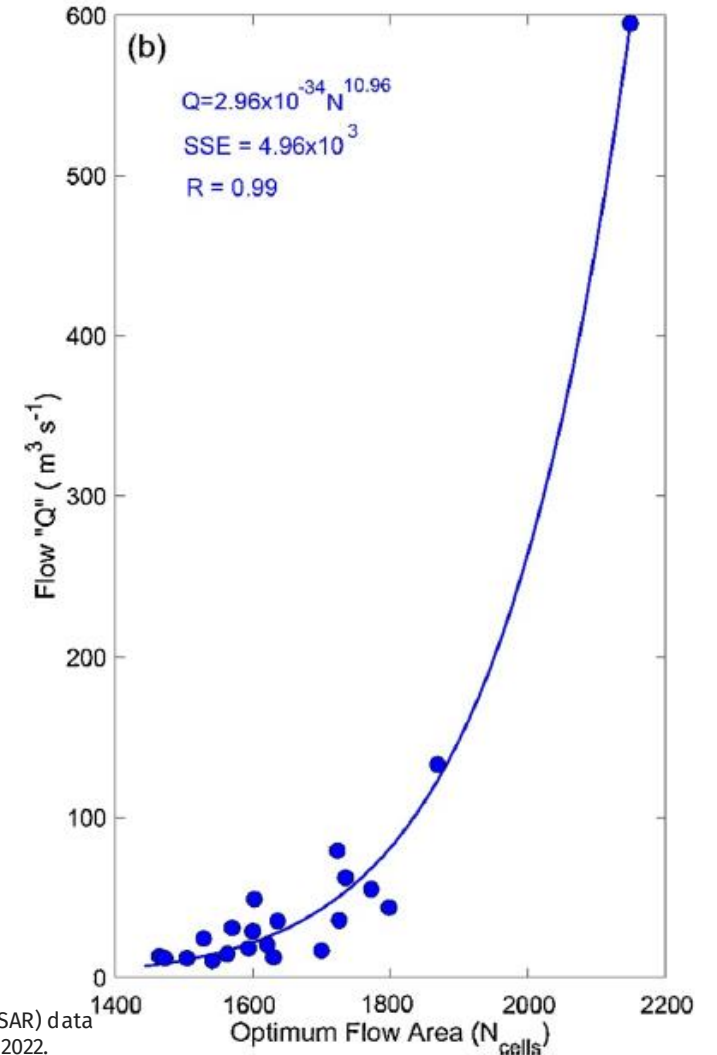
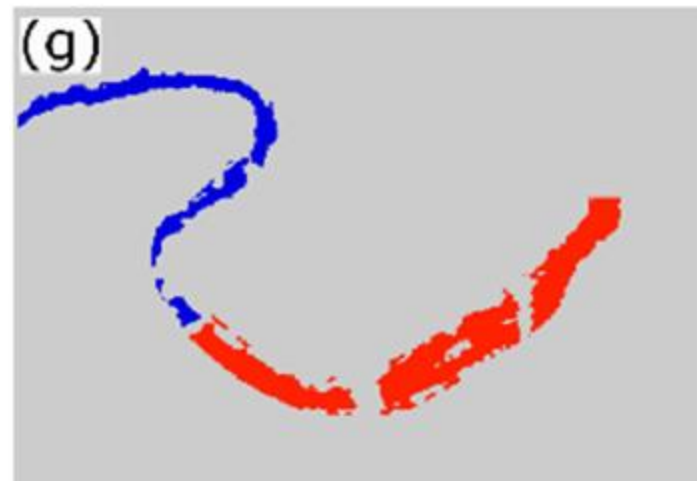
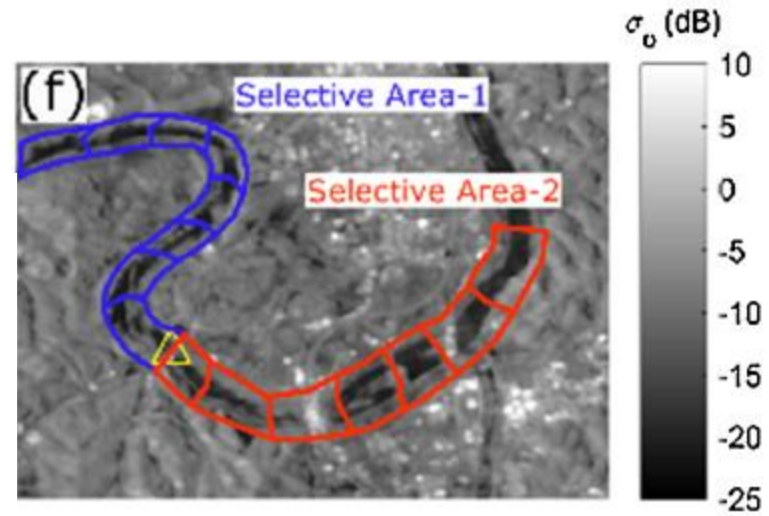
Data and methods

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.



IRRIGATION PERFORMANCE ASSESSMENT

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

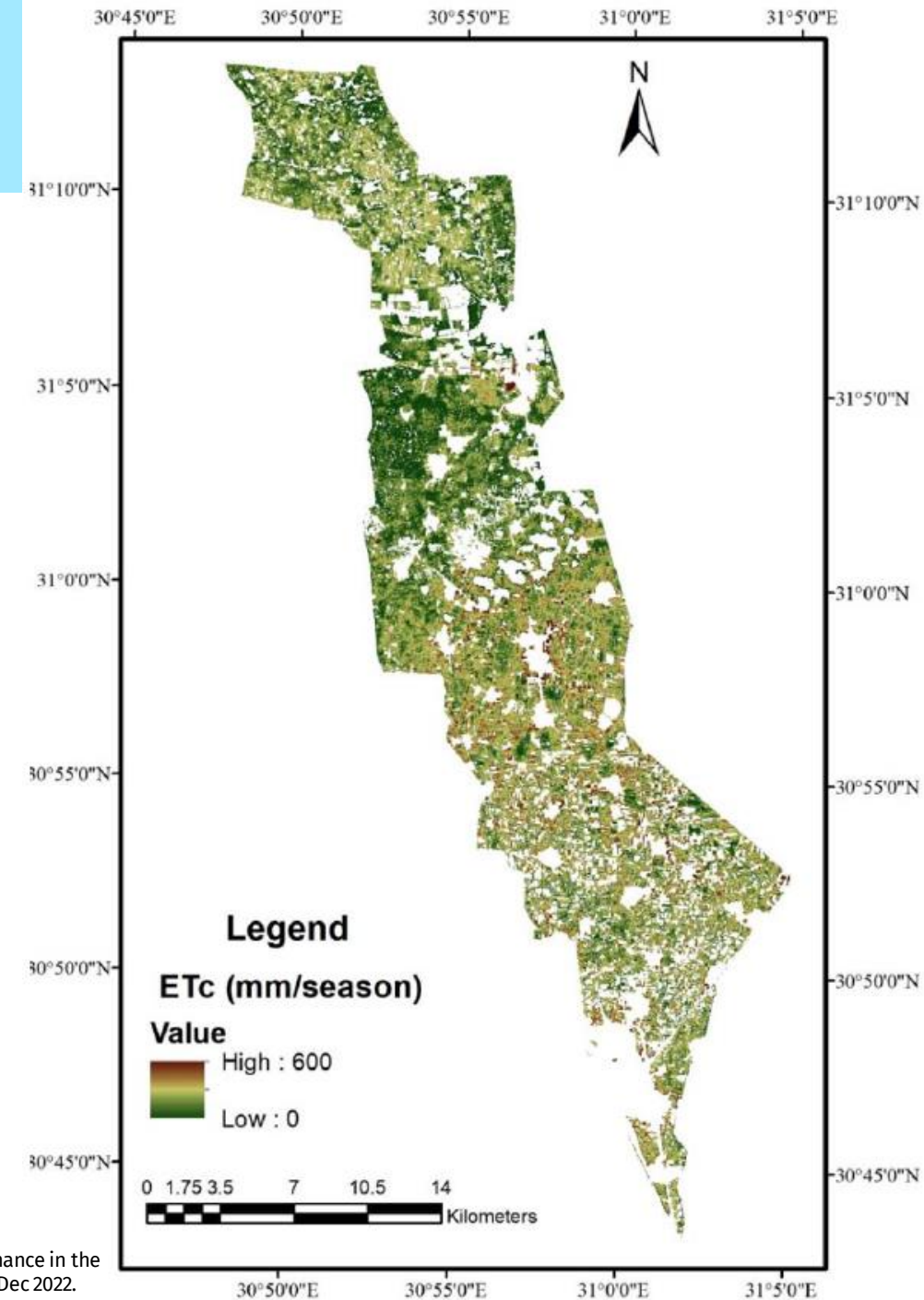
Data and methods

Multi spectral satellite images of LandSAT 8.

Surface Energy balance model (SEBAL) to compute ET_c OR

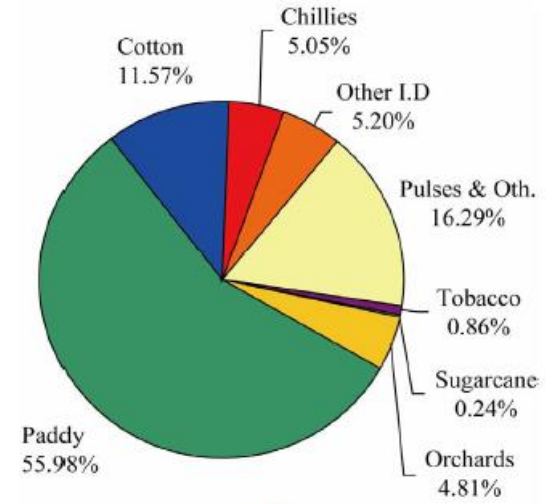
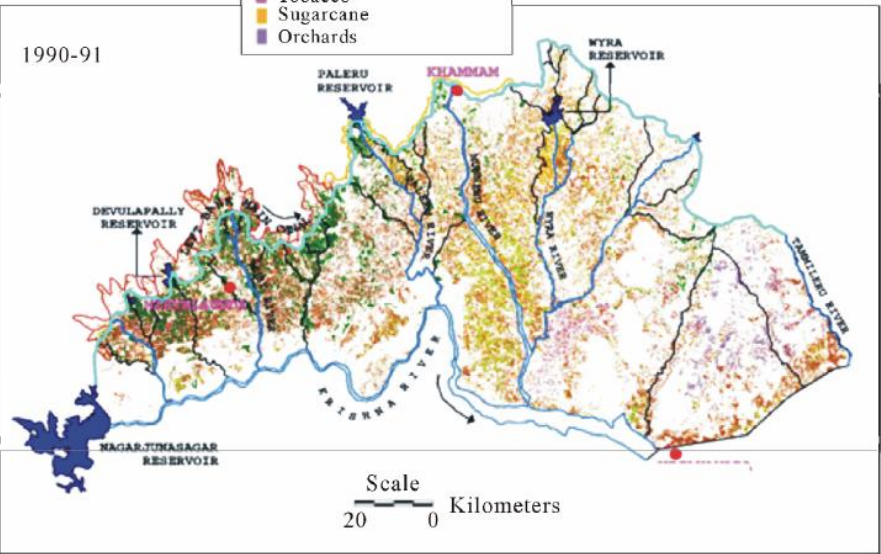
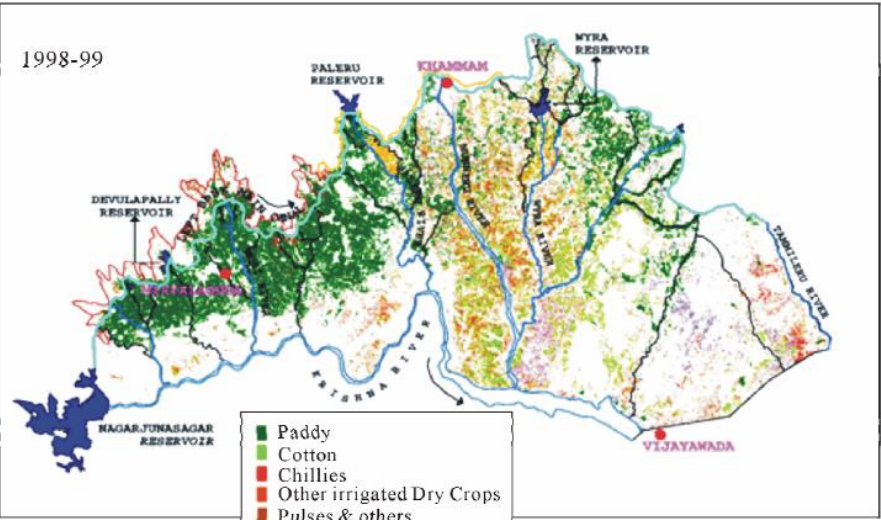
Data sources: USGS Earth Explorer

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

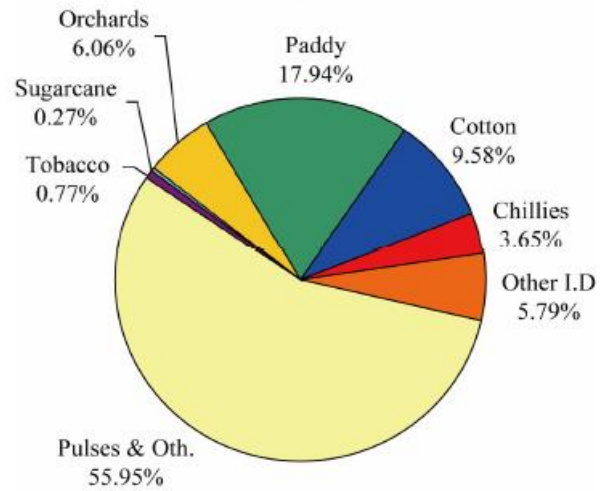




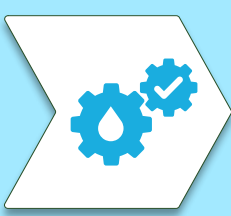
REMOTE ASSESSMENT OF CROPPING PATTERN



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

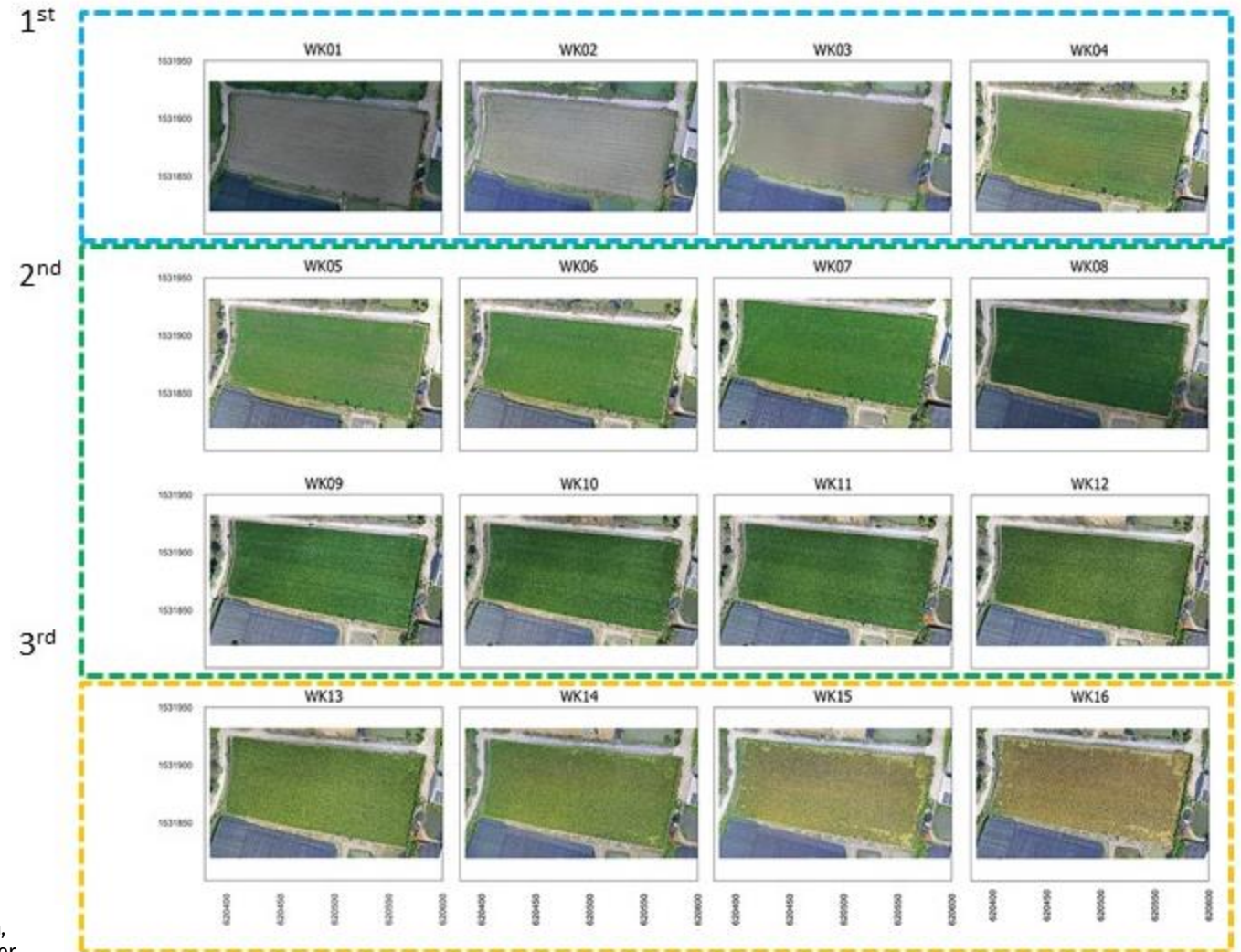
Multi spectral images of various EOS and UAV can be used.

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

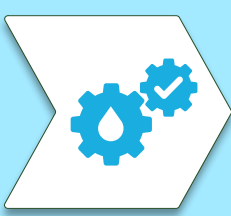
Data sources: ESA Sentinel Open Access Hub, and UAV.

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

Weekly images of paddy field (10m x 10m)

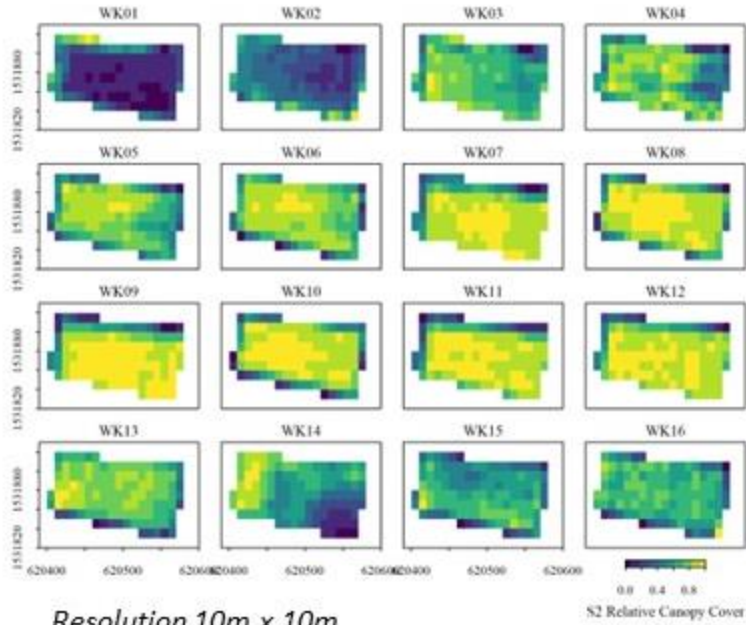


UAV orthomosaic of 16 weeks.

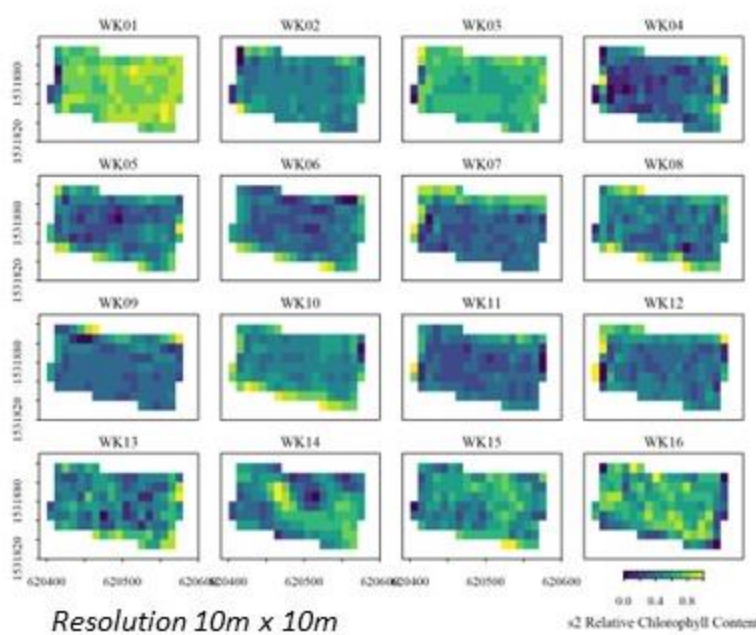


CROP MANAGEMENT

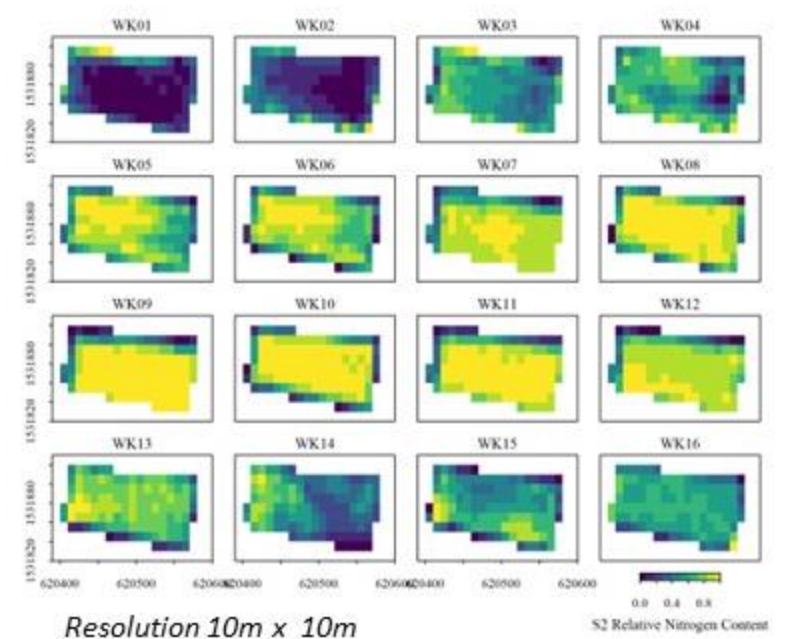
Chlorophyll content



Relative Chlorophyll Content (TGI)



Relative Nitrogen Content (GNDVI)



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

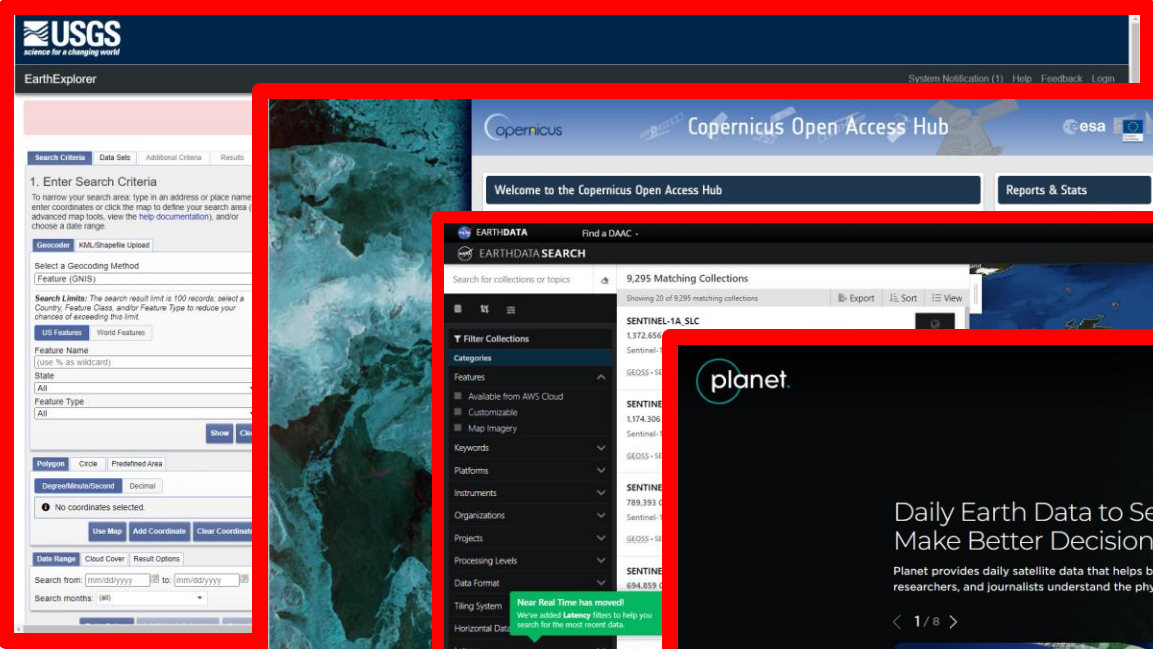
$$Relative\ Chl = \frac{(TGI - TGI_{min})}{(TGI_{max} - TGI_{min})}$$

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

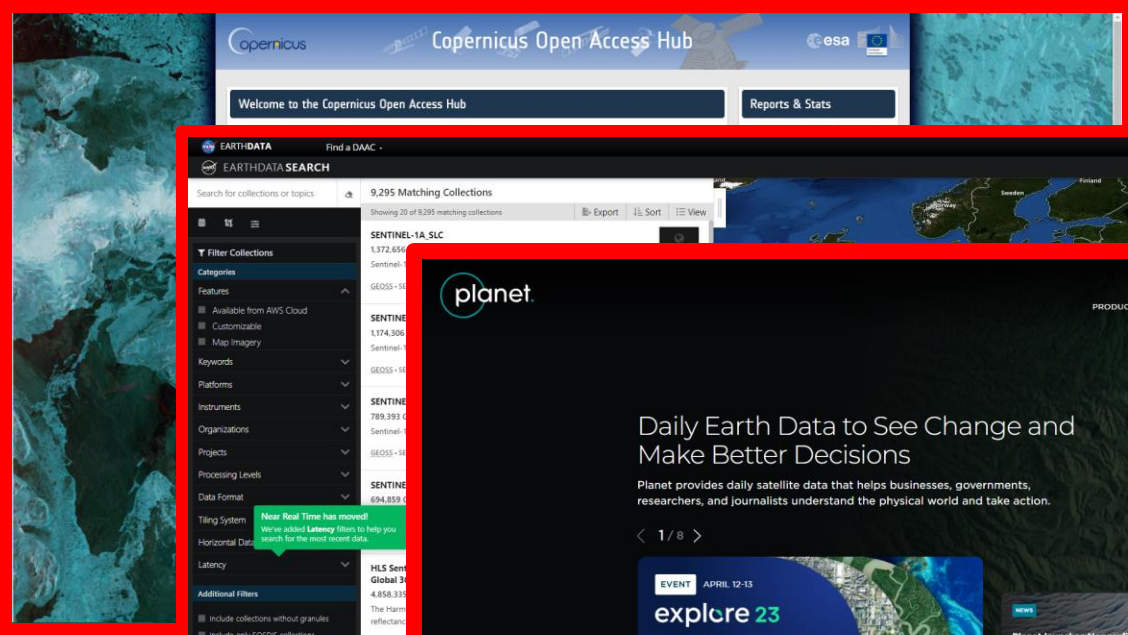
*Triangular greenness index



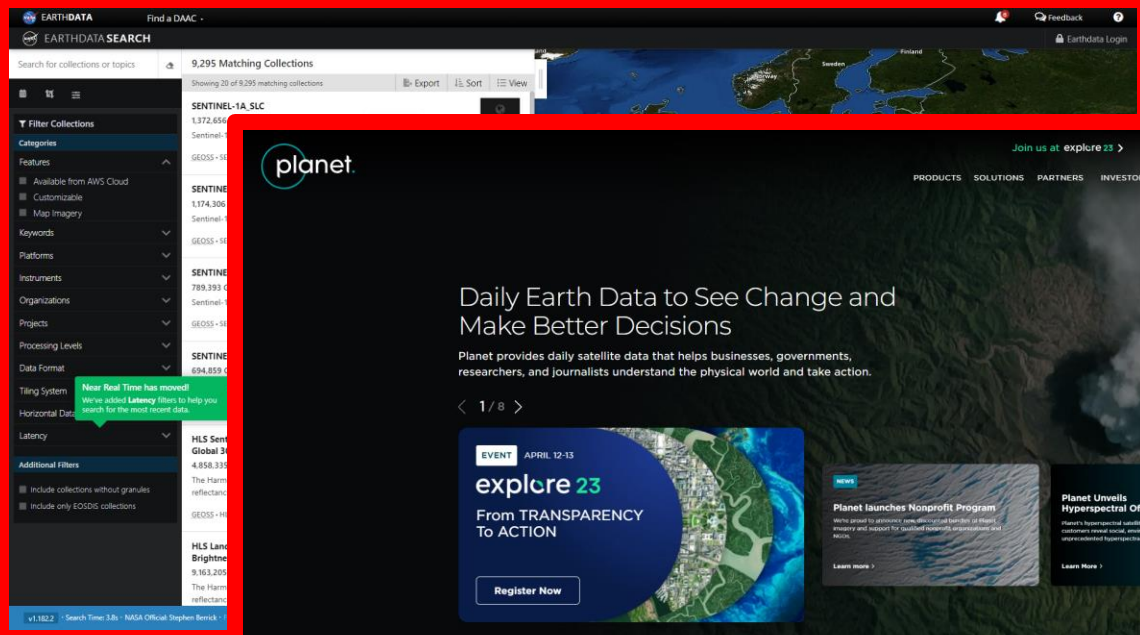
REMOTE SENSING DATA RESOURCES



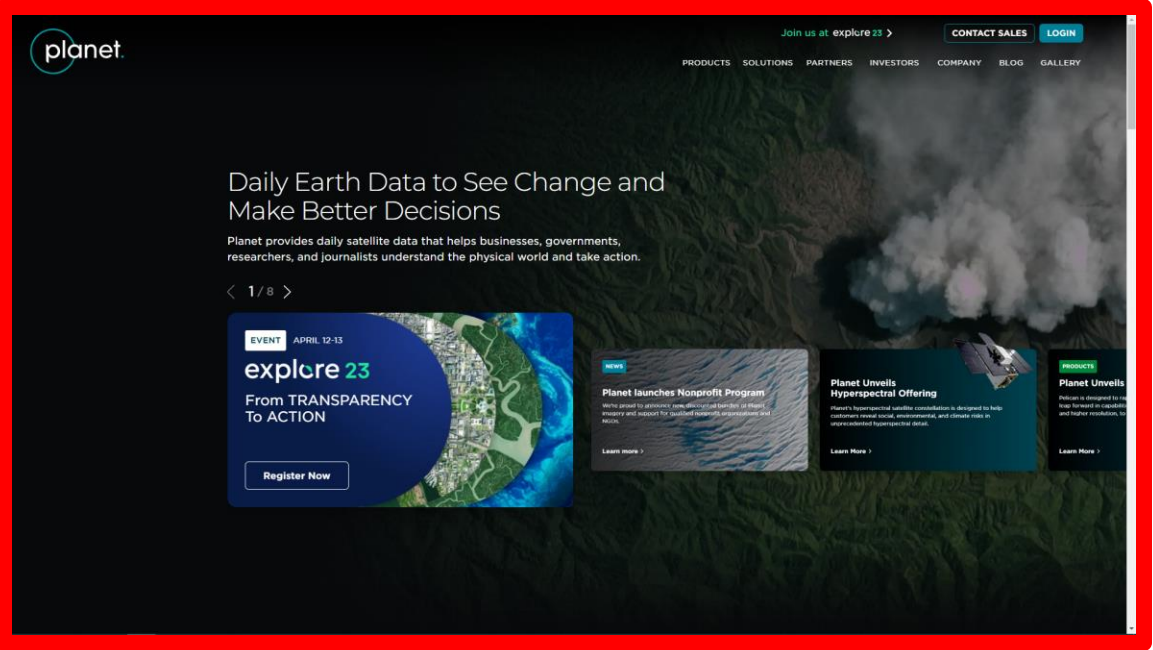
USGS Earth Explorer



ESA Copernicus Open Access Hub



NASA Earth Data



PlanetLab



ONLINE READY TO USE RESOURCE

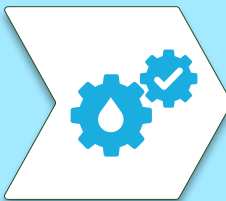
Earth Observation Satellite (EOS) Data Analytics <https://eos.com/>

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

The screenshot shows the EOS Data Analytics website interface. At the top, there is a navigation bar with links for Products, Company, Partnership, EOS SAT, Blog, and Contact Us. A countdown timer indicates that EOS SAT-1 will be launched in 10 days, 17 hours, 40 minutes, and 06 seconds. Below the timer, there is a section titled "BUILD YOUR OWN EOS SAT SATELLITE" with a "LAUNCH THE SATELLITE" button. The main content area features a large map of a field with various crop types color-coded. A legend on the right side of the map lists crop types for the 2022 season: Wheat (red), Sunflower (orange), Corn (Maize) (yellow), Buckwheat (green), Wheat barley (light green), Millet (dark green), Rapeseed (light blue), and Soybeans (blue). To the left of the map, there is a section titled "Crop Type Classification Using Remote Sensing" with a sub-heading "Classification of field crops is an essential part of agriculture as a business. Identifying crops using traditional methods can be quite a daunting task." Below this, there is a paragraph explaining that EOSDA offers a faster and much easier way of solving this problem by combining Synthetic Aperture Radar (SAR) data with optical imagery. At the bottom left, there is an orange button that says "GET CROP CLASSIFICATION".

The infographic is titled "Crop Classification Solution In Numbers" and is set against a dark background. It features six key metrics, each represented by an icon and a brief description:

- Accuracy up to 90%**: Represented by a checkmark icon. Description: "Crop type maps with an accuracy of up to 90%, depending on the completeness of ground data and availability of regular satellite scenes."
- Resolution 10 meters**: Represented by a crosshair icon. Description: "Get cropland masks at a 10-m resolution in .geotiff or .shp formats."
- Field size from 3 ha**: Represented by a diamond icon. Description: "Crops identified for any area, even as small as 3 ha."
- Coverage AOIs in 195 countries**: Represented by a globe icon. Description: "Our algorithm identifies crops almost anywhere on Earth."
- Delivery rate from 1 month**: Represented by a circular arrow icon. Description: "If conditions are favorable, our qualified RnD team requires only several weeks to complete research and deliver an accurate crop classification map to you."
- Crop types over 15**: Represented by a plant icon. Description: "Our trained neural networks can classify over 15 different types of crops."



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MERCI
THANK YOU