CLMS: global EO products for Natural Heritage monitoring

EO for Cultural and Natural Heritage 2024 workshop

Presenters: Simone Balbo - JRC

Andrea Lupi - JRC

15-16 October 2024

PROGRAMME OF THE EUROPEAN UNION

Copernicus Europe's eyes on Earth

Land Monitoring

Implemented by European Environment Agency

European Commission

Land Monitoring

Copernicus and Heritage

- "*Nowadays, tangible and natural cultural heritage is in danger, because of natural hazards and Climate Change, as well as man-made threats and criminal activities. It is our collective responsibility to act.* ***The data and information offered by the Copernicus programme can contribute*** *to tangible and natural cultural heritage preservation and management.*" [Copernicus website - 2018]

- "Heritage is our **legacy from the past**, what we live with today, and what we pass on to future generations. Our cultural and natural heritage are both irreplaceable **sources of life and inspiration**." [UNESCO]"

- Natural Heritage sites (UNESCO):
  - ''*some of the Earth's most valuable natural areas recognized as being of Outstanding Universal Value (OUV) to humanity for their global significance to nature conservation*''
  - **266 NH sites :** 218 NH sites **+** 39 mixed sites (recognized for both natural and cultural criteria)
  - **3,500,000 km²** (more than the size of India) - across more than **100 countries**

The Copernicus Land Monitoring Service (CLMS)

Land Monitoring

- "*The **key challenge** of the use of EO data for cultural heritage monitoring is the **development of tailored products**, more than the necessity of new types of space-based observations, therefore **research is necessary** in this case*" [Copernicus - 2018]

Role of EO in C&N heritage monitoring (examples)

- "*...arid region of the Cholistan Desert in eastern Pakistan. Here, hundreds of archaeological mound surfaces are threatened by the **accelerated transformation of barren lands into new irrigated agricultural lands**.*" [F.C. Conesa et al. 2023]
- *"Climate change in the Arctic is impacting cultural heritage on a devastating scale, ranging from **coastal erosion** [...]. Climate change has allowed the pillaging of woolly mammoth tusks from **thawing ground**, many from archaeological sites [...]*" [B. Lintott et al.]

- **CLMS** products and services can be useful for **assessing and monitoring Natural Heritage** and can be applied at different scale.

The Copernicus Land Monitoring Service (CLMS)

Land Monitoring

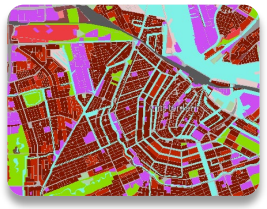
- Land cover and land use mapping
- Priority area monitoring
- Satellite data
- Bio-geophysical parameters
- Ground motion monitoring
- Reference and validation data

- **Geographical** information on **land cover and its changes, land use, vegetation** state, **water cycle** and Earth's surface **energy variables** on European and global levels for environmental applications
- **Harmonized** and **consistent** in time and space
- Products and manuals are **free** and **open**
- Implemented by **JRC** and **EEA**
- Website: https://land.copernicus.eu/

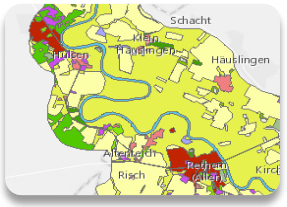
CLMS at EEA overview

Land Monitoring

Urban Atlas
2006-12-18-21

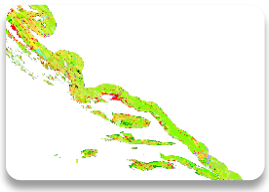


Riparian Zones
2012-18-24



Protected Areas
2006-12-18-21

Coastal Zones
2012-18-24

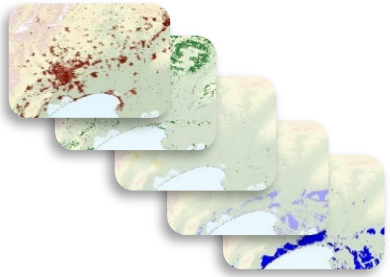


VHR optical images
(2-5m pixel)

CLC & CLCC
1990-2000-06-12-18-24

CLC+ BackBone
2018-21-23

High Resolution Layers
2006-09-12-15-18-various

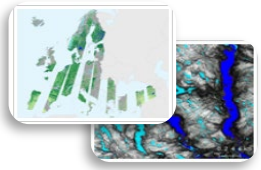


HR optical images
(Sentinel 2 10-20m pixel)

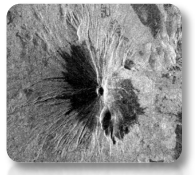
EU-Hydro
Next update 2021

European Ground Motion Service
Yearly 2018 to 2022-2023

Biophysical Parameters
Near Real Time



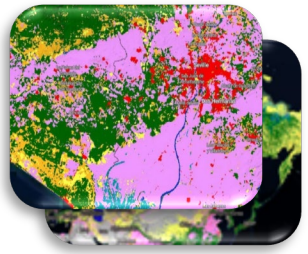
HR radar images
(SRTM, Sentinel 1 14m pixel)



CLMS at JRC overview

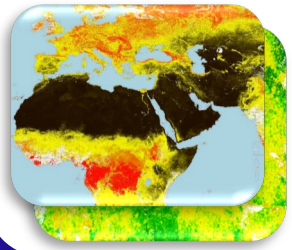
Land Monitoring

Global Land Cover
2015-16-17-18-19-24



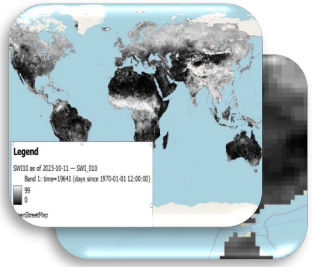
Global Image Mosaic
S2GM 2017-present

Vegetation



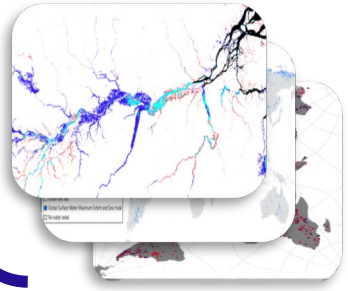
FAPAR 2016 - present
NDVI 2020 - present
LAI 2014 – present
...

Energy



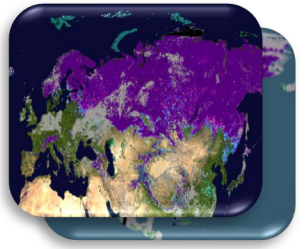
Soil Water Index 2007 - present
Surface Soil Moisture 2014-present
Land Surface Temperature
2021 - present
...

Water



Water Bodies 2020 - present
Lake turbidity 2019 - present
Lake surface water temperature
2016 - present
...

Cryosphere



Snow Cover Extent 2018 - present
Snow Water Equivalent 2008-present
...

Hot Spot Monitoring

Copernicus4GEOGLAM - agriculture
HSM – biodiversity

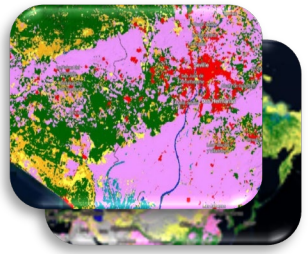
Reference & Validation

GBOV 2013 - present

CLMS at JRC overview

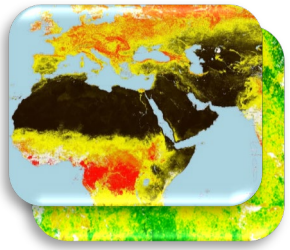
Land Monitoring

Global Land Cover
2015-16-17-18-19-26



Global Image Mosaic
S2GM 2017-present

Vegetation



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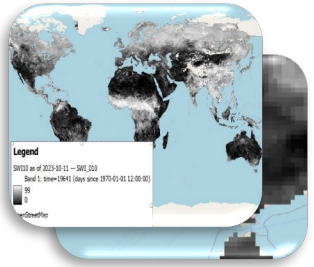
NDVI 2020 - present
LAI 2014 – present
...

Energy



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Land Surface Temperature
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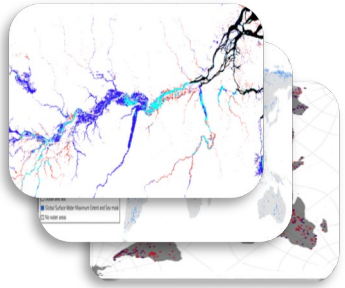
Water



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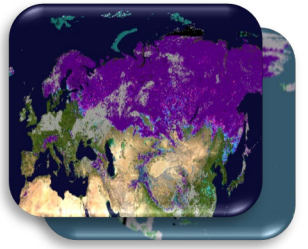
Cryosphere



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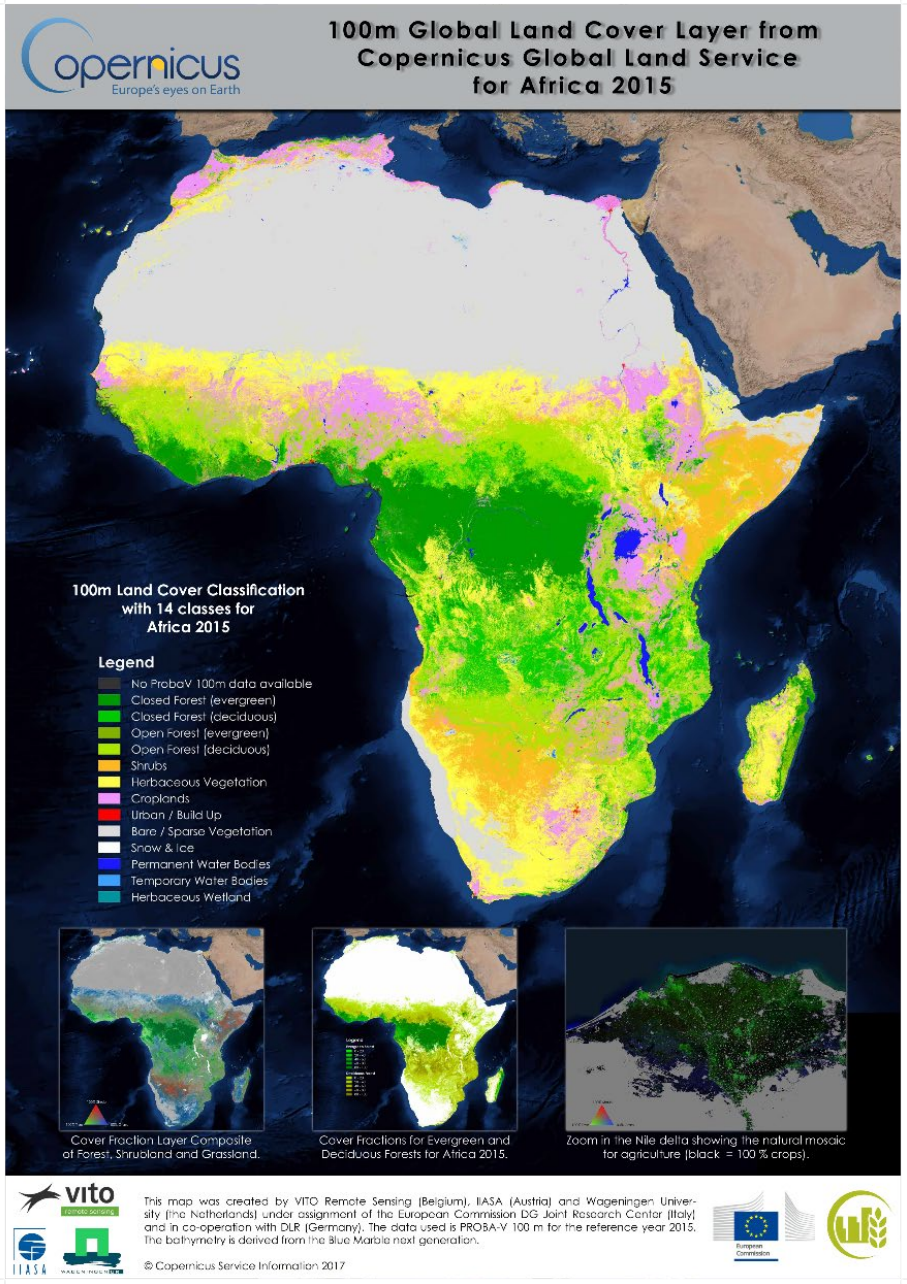
Hot Spot Monitoring

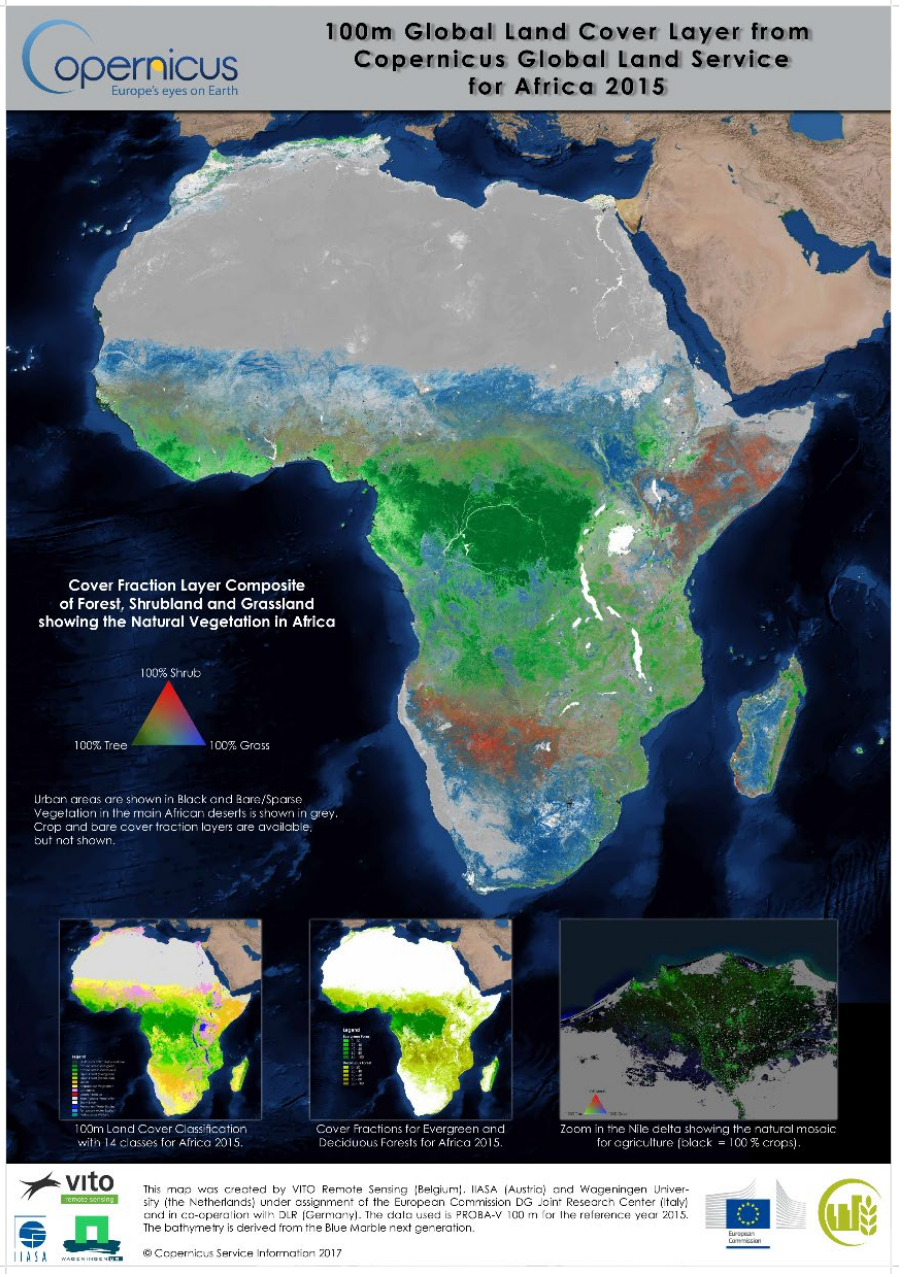
Copernicus4GEOGLAM - agriculture
HSM – biodiversity

Reference & Validation

GBOV 2013 - present

Past: Global Land Cover map - 100m



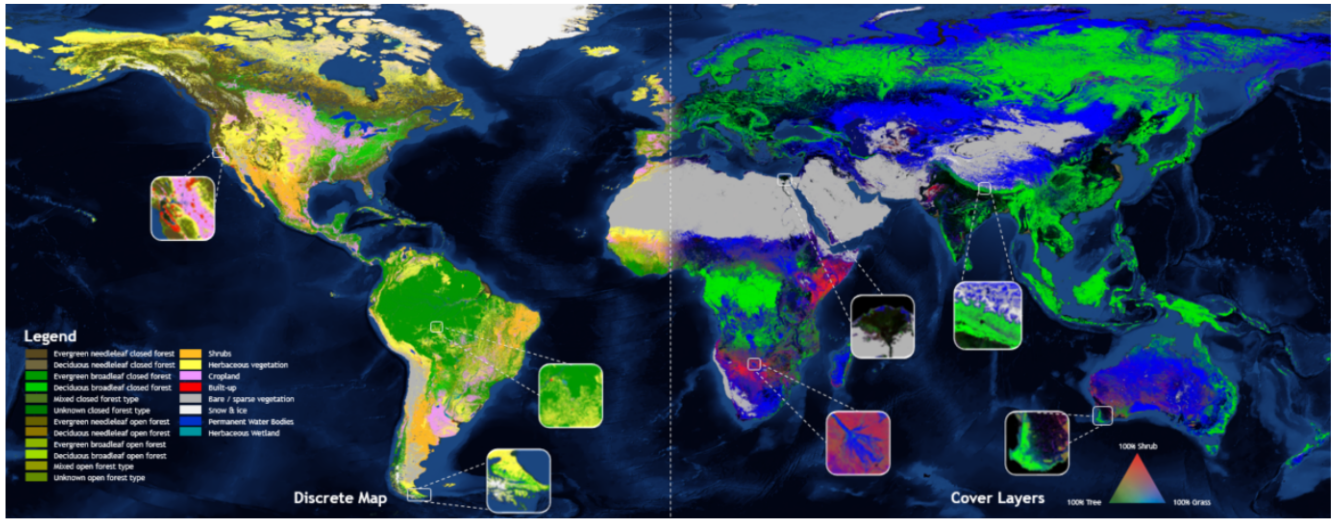


The number 1 downloaded product

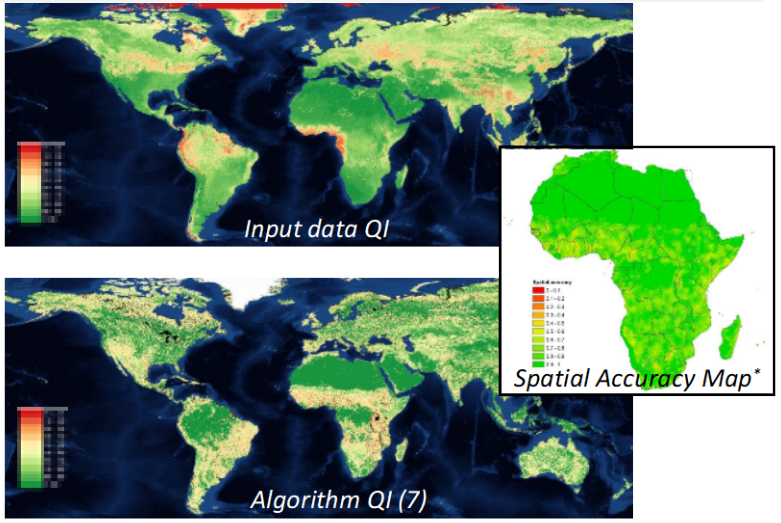
Very good user feedback

Present: Global Land Cover map - 100m

*The Global Land Cover Layers: more than a 'map', it is a systematic **service** providing dynamic, **yearly, user-oriented global** land cover maps available from 2015 to 2019*



Discrete Map (21 classes)



10 Continuous Covers (0-100%)

Permanent water is derived from GSWE (Pekel et al.)
Built-up is derived from WSF (Marconcini et al.)

Quality Indicators

(*) example over Africa, global maps under release test

Continuous Covers	
Bare	Snow
Crops	Tree
Grass	Urban
Moss	Permanent water
shrub	Seasonal water

Collection	Status	Spatial	Temporal	Sensor	Training (10m)	Accuracy[1]
1	Demonstration	Africa	2015	PROBA-V	26.000 ('15)	74%
2	**Operational Demonstration***	**Global Africa**	**2015 2015 – 2018**	**PROBA-V**	**141.000 ('15)**	**80%**
3	In production	Global	2015 – 2019	PROBA-V, Sentinel-2	155.000 ('15)	80%
-	Planned	Global	2019 – …	Sentinel-1, Sentinel-2	tbd ('20)	Target ≥80%

(*) under release test

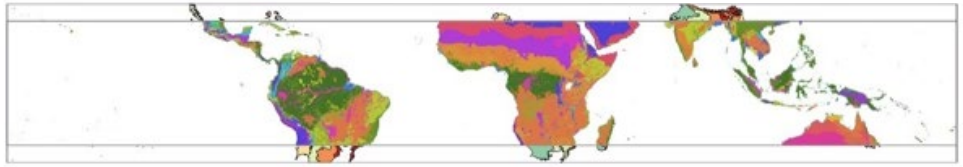
(1) independent validation per CEOS-LPV

Future: Land Cover & Forest Monitoring - 10m

Land Cover Characteristics	Land Surface Categories	Land Cover Map	Land Cover Change Map	Land Cover Map	Land Cover Change Map	Land Cover Characteristics
Sub-annual	Sub-annual	Annual	Annual	Annual	Annual	Annual
10m	10m	10m	10m	100m	100m	10m
2020-2026	2020-2026	2020-2026	2021-2026	2020-2026	2021-2026	2020-2026
Per pixel based feature extractions	Categories of direct observable surface properties	Land cover map minimum of 11 land cover classes	Annual land cover changes	Land cover map, cover fraction layers	Annual land cover changes	Per pixel based yearly statistics

Tree Cover Density	Tree Cover Presence Change
Annual	Annual
10m	10m
2020	2021-2026
Tree cover in percent per pixel	Annual tree cover presence changes

- Intermediate products for further analysis/processing
- Global coverage/tropical coverage
- Increased spatial resolution -> 10 m
- Unprecedented combination of spatial and temporal resolution
- Product release in early 2025



Land
Monitoring Service

High Resolution Hot Spot Monitoring

PROGRAMME
OF THE EUROPEAN UNION

Copernicus
Europe's eyes on Earth

Land
Monitoring

Implemented by

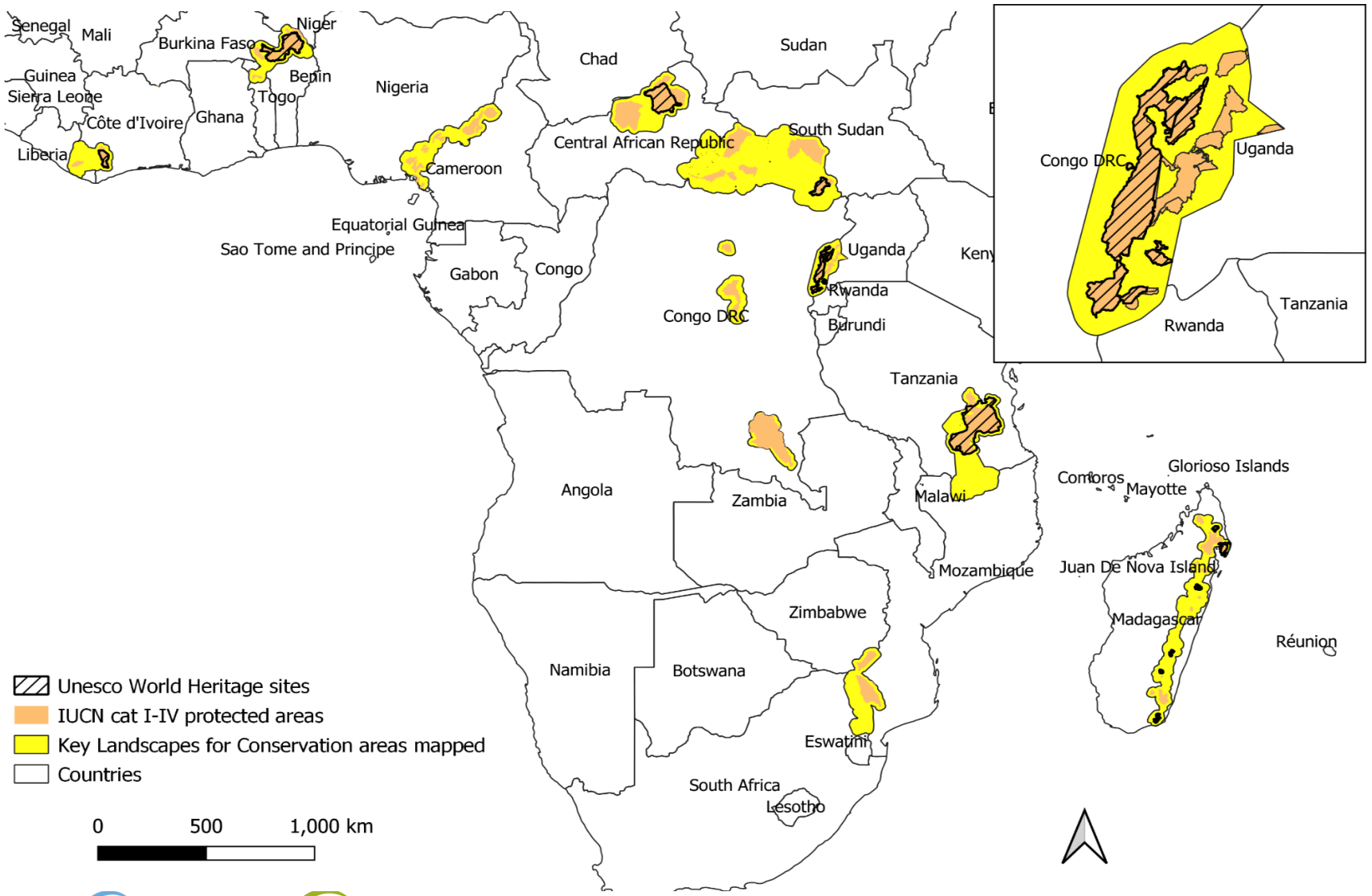
European
Environment
Agency

European
Commission

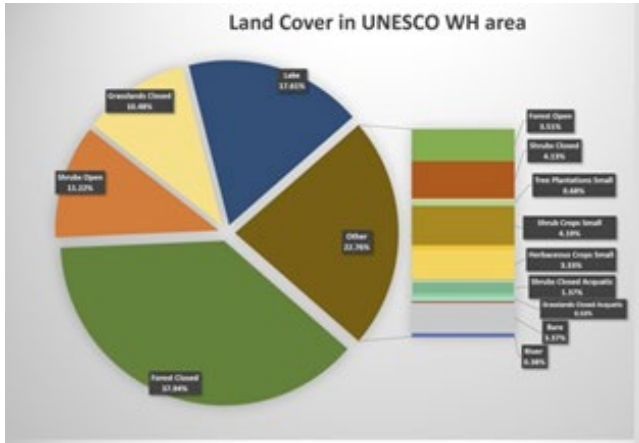
Hot Spot Monitoring – Aim, Status, Evolution

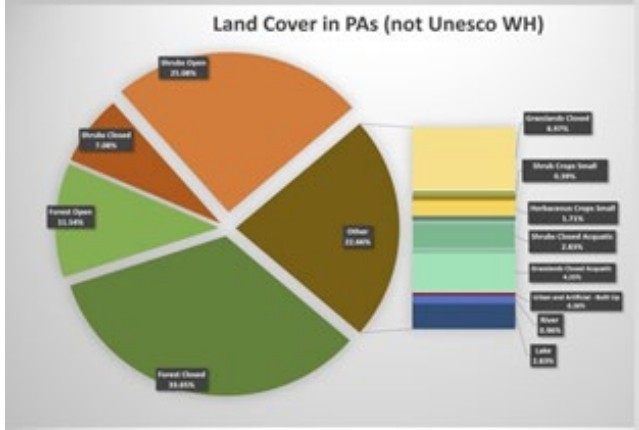
- ★ To produce land cover and land cover change maps and related indicators over specific Areas of Interest (AOI) using medium to high resolution satellite data (from 1 to 30m pixel size)
- ★ To provide detailed land information on specific areas of interest, globally
- ★ To answer to ad-hoc requests (e.g. from DG INTPA, EU Delegations, the BIOPAMA Program, UNESCO) within the domain of the sustainable management of natural resources
- ★ To complement the near real time global monitoring service at low resolution
- ★ 19 AOI mapped along the first project phase **Hot Spot I**
- ★ About 1.3 Mio km^2 (for comparison: Tanzania is about 947,300km^2)
- ★ Next project phase **Hot Spot II:** launch expected during Q4 - 2024

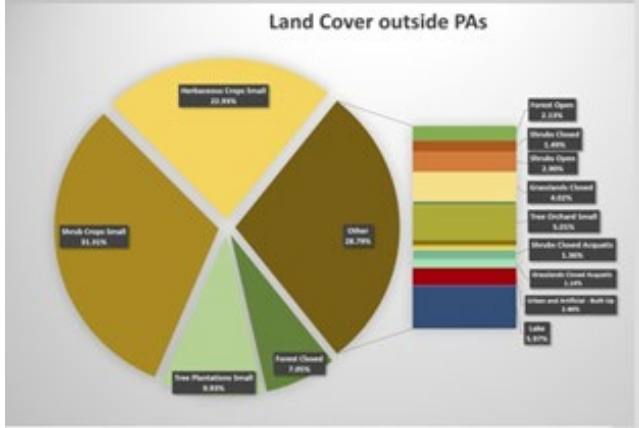
Hot Spot Monitoring – Natural Heritage Observation

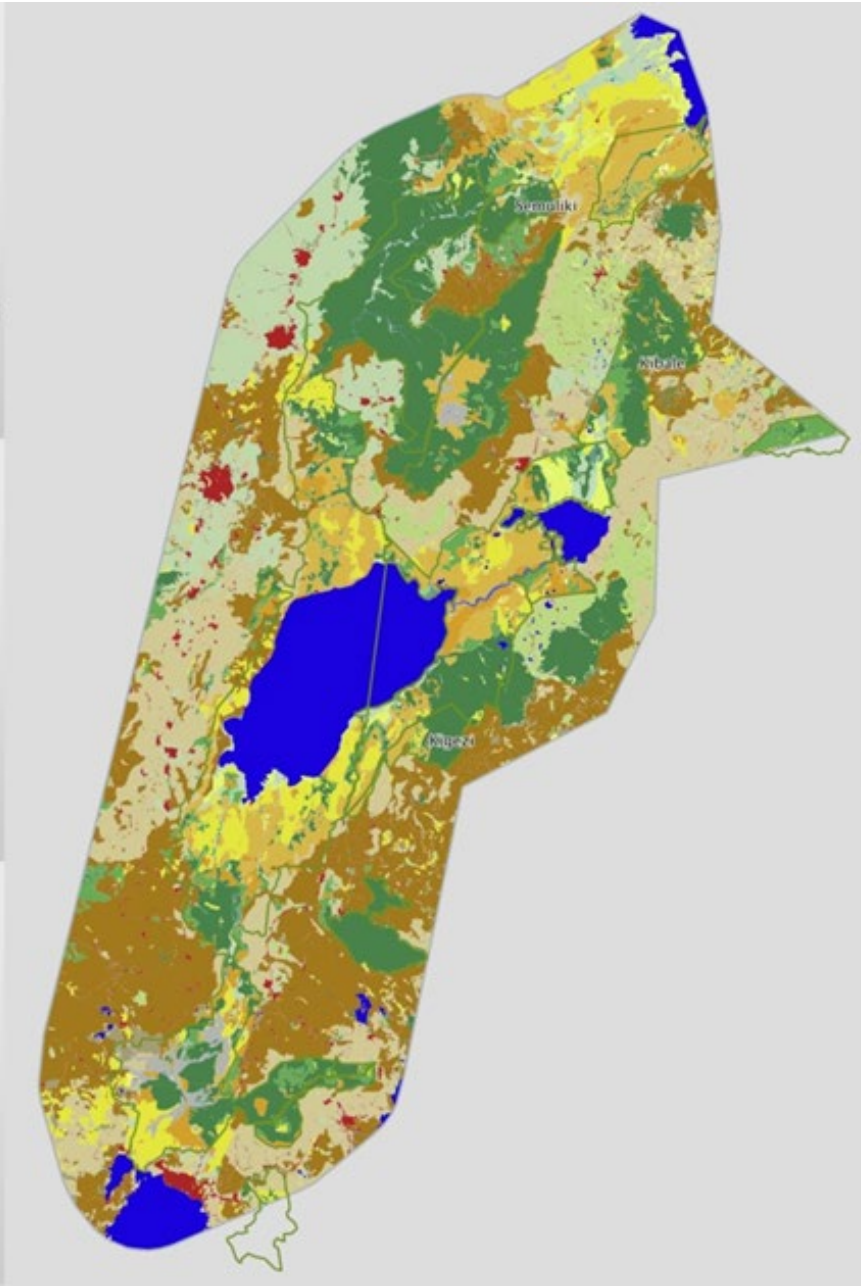


KLCs covering UNESCO WH sites - VIRUNGA

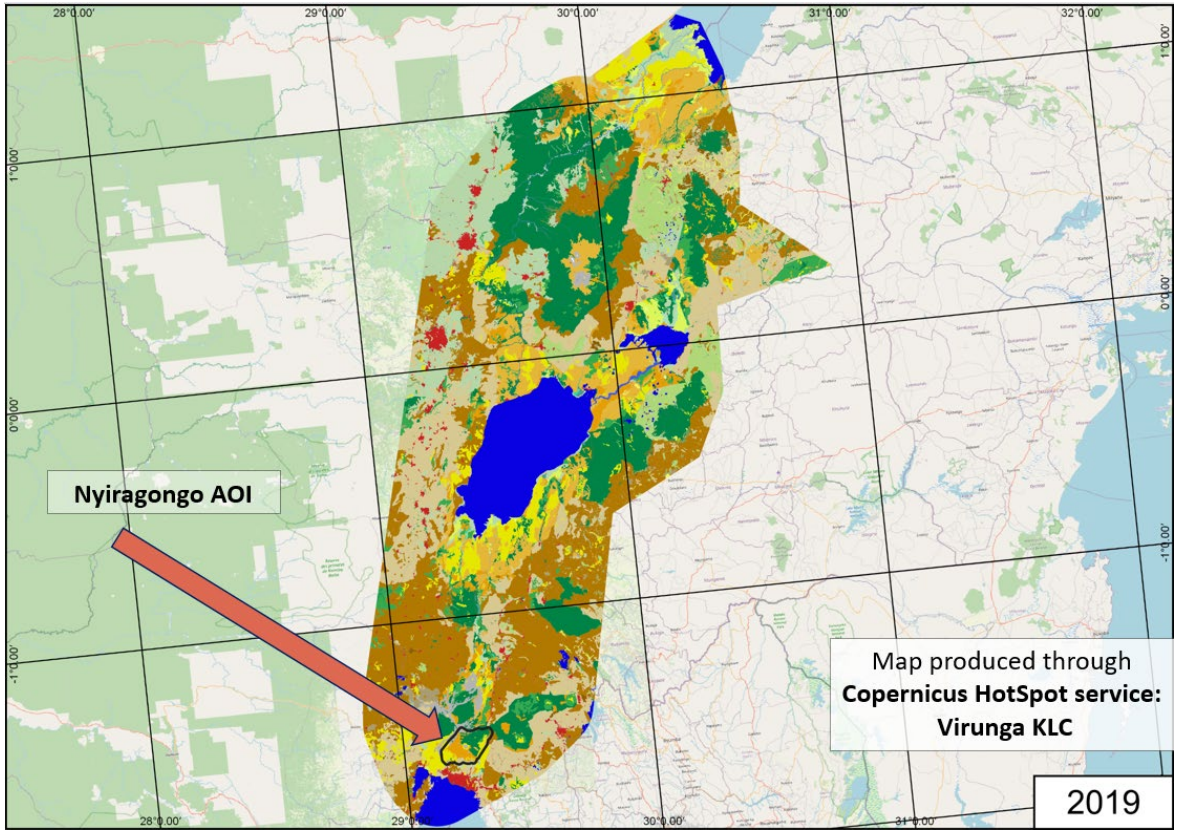




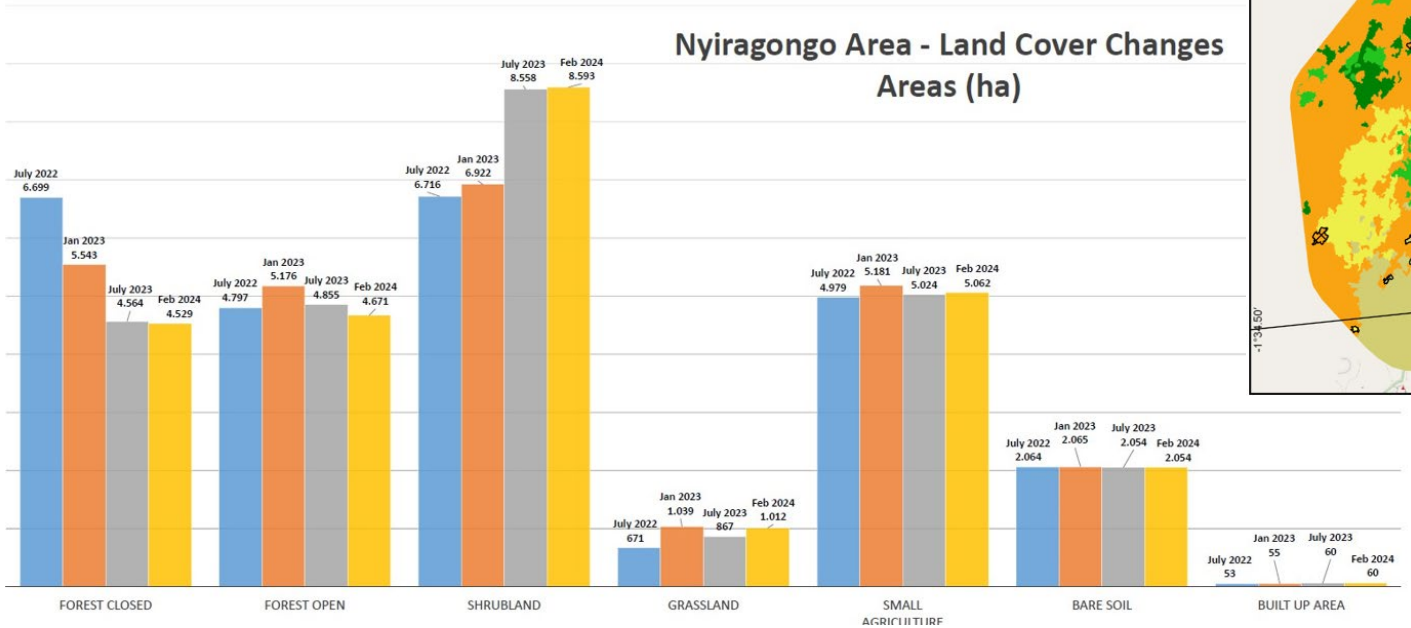


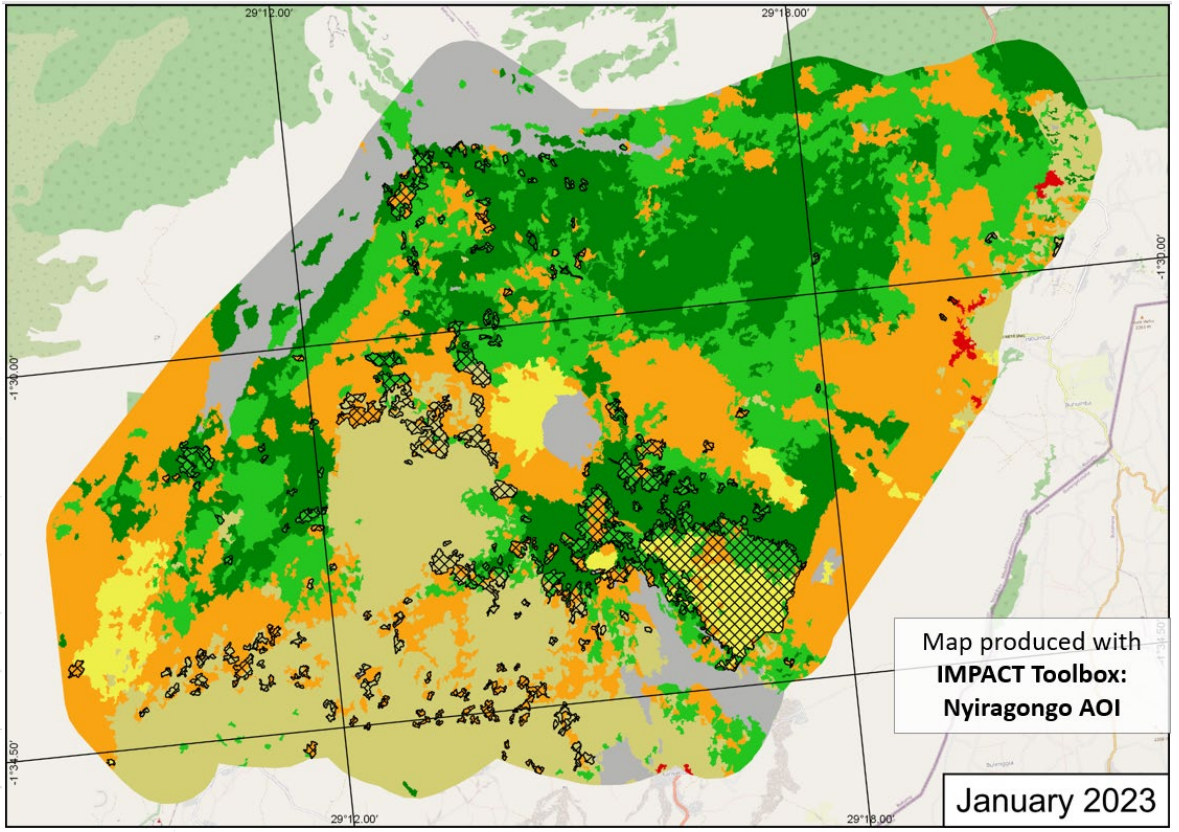


Hot Spot Monitoring – Natural Heritage Observation



Hot Spot Monitoring – use case



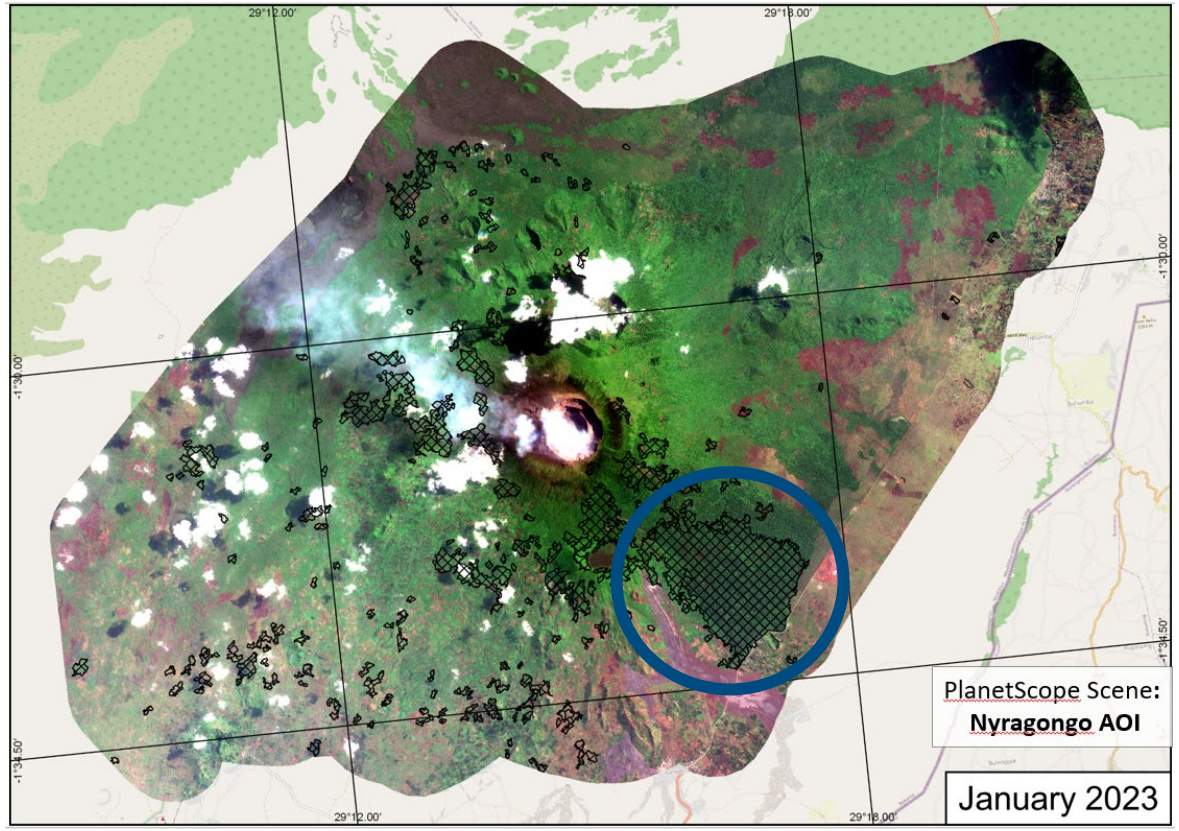


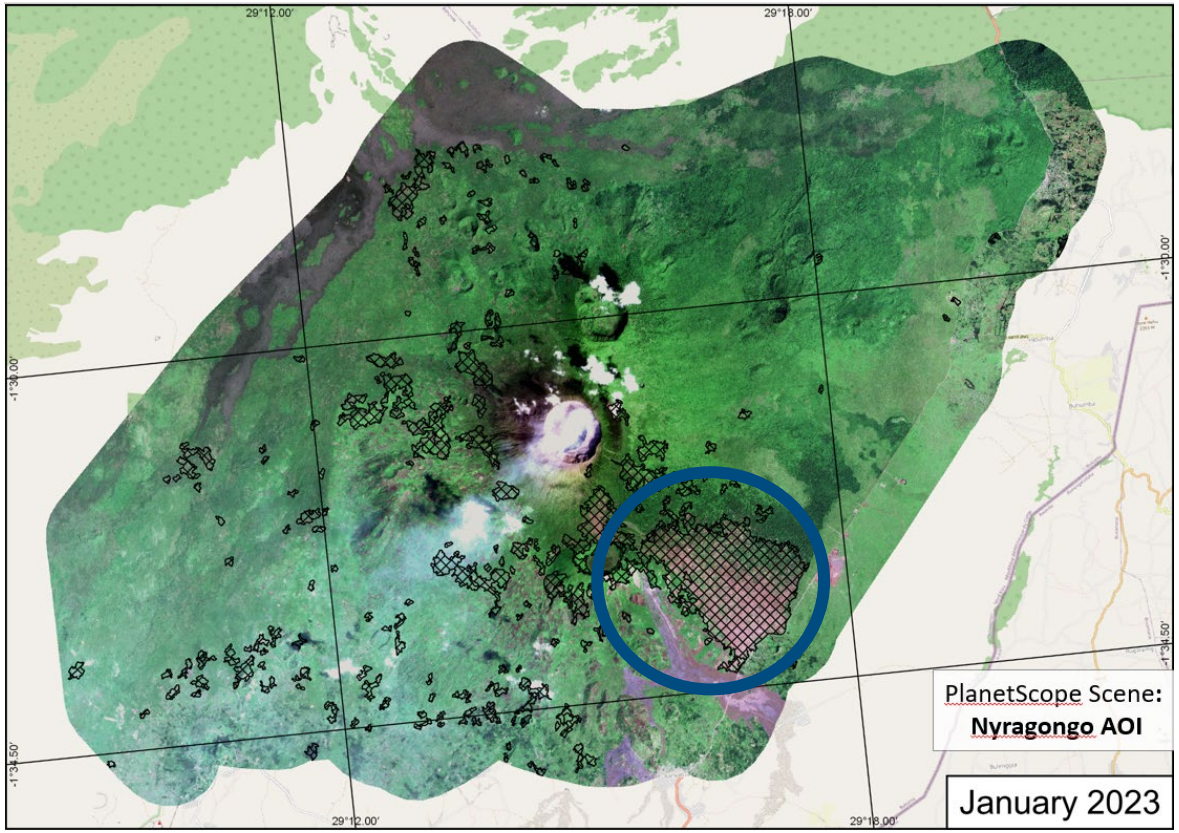
https://forobs.jrc.ec.europa.eu/IMPACT

PROGRAMME OF THE EUROPEAN UNION

Implemented by European Environment Agency

Hot Spot Monitoring – use case





"In DRC, Virunga deforestation escalates as fighting sends refugees into park" – Mongabay – news.mongabay.com

DOPA Services: Set of applications that can be used primarily to assess, monitor, report and possibly forecast the state of and the pressure on protected areas at multiple scales.

Digital Observatory for Protected Areas (DOPA) Explorer

Parc national des Virunga

Congo (Democratic Republic of the)

WDPA ID	Designation Type	Year	IUCN Category	Reported Area	Calculated Area	Type
478291	International	1996	Not Reported	8,000.00 km^2	7,822.57 km^2	Terrestrial

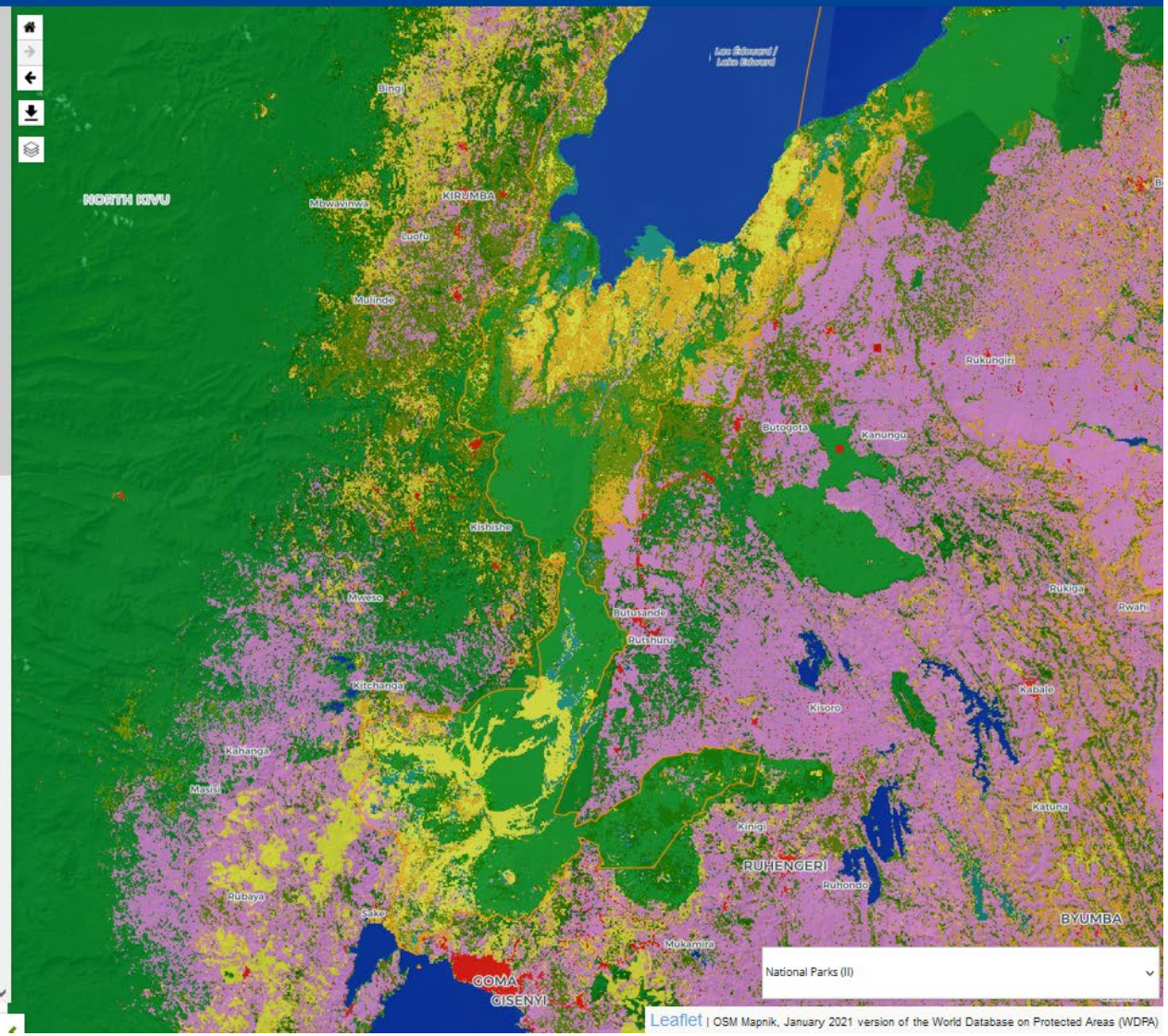
Parc national des Virunga *is in* ***Congo (Democratic Republic of the)****, has been designated as* ***Site Ramsar, Zone Humide d'Importance Internationale*** *at International level in* ***1996****. It covers* ***7,822.57 km^2***

- Happening Now
- Diagnostic
- Climate
- Ecosystems
- Ecosystem Services
- **Land Cover**

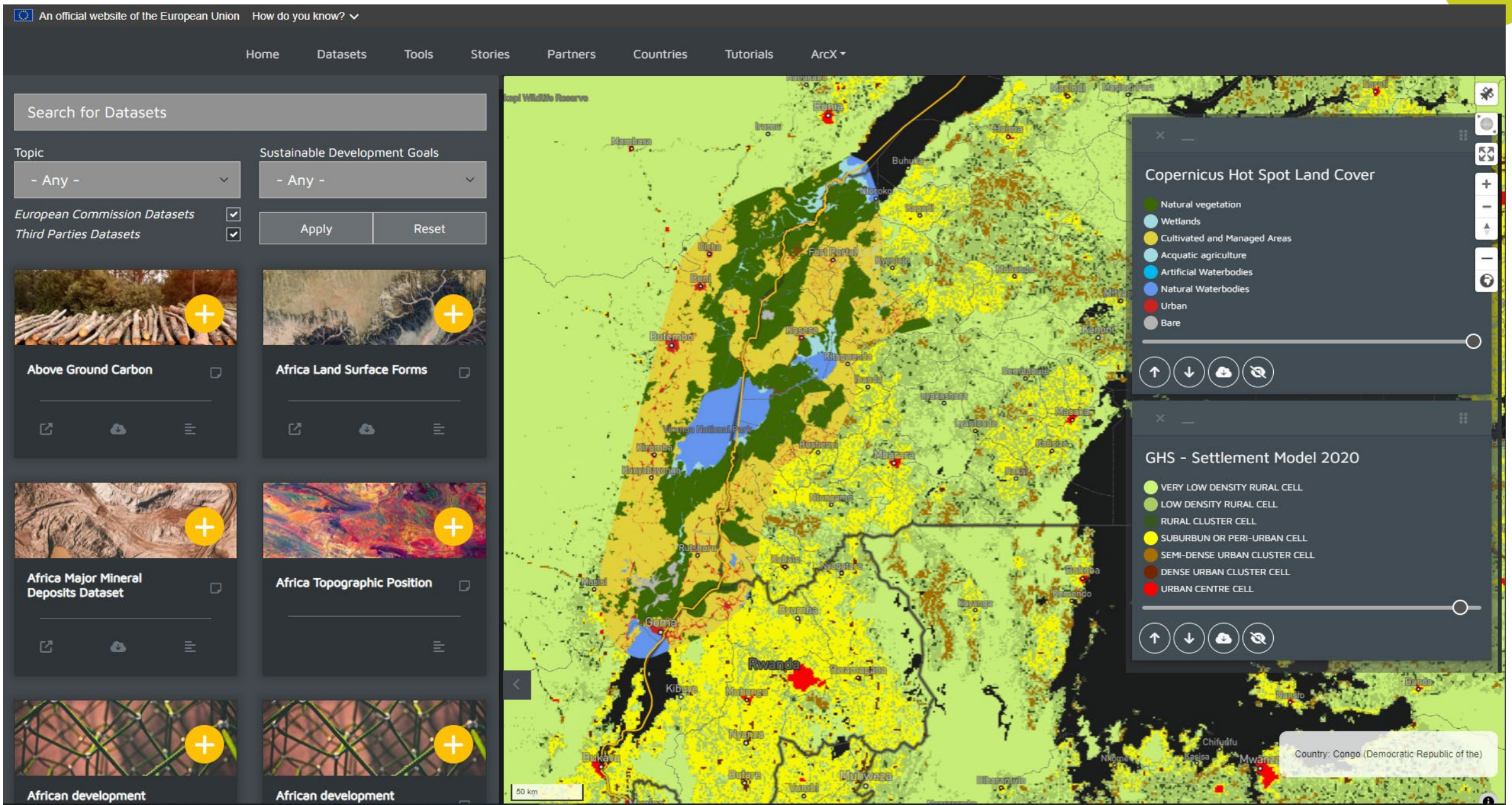
Copernicus Global Land Cover 2019

Using the second aggregation level, the land cover classes are provided for this protected area for the year 2019 km² and %.

Copernicus Global Land Cover 2015



Africa Knowledge Platform: gateway to data and information on Africa



Conclusions

- The European Copernicus programme can help to assess, monitor and report land cover change at natural WH sites
- The data shows how land cover changes have affected different WH sites, also relative to their surroundings
- This information can inform site management, monitoring and reporting
- The Hot Spot II programme will be launched in Q4 2024
- As operational services CLMS provide continuity of the products, allowing users to develop their own down stream applications

Thanks a lot for your attention

Thank you!

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